CIVIL ENGINEERING

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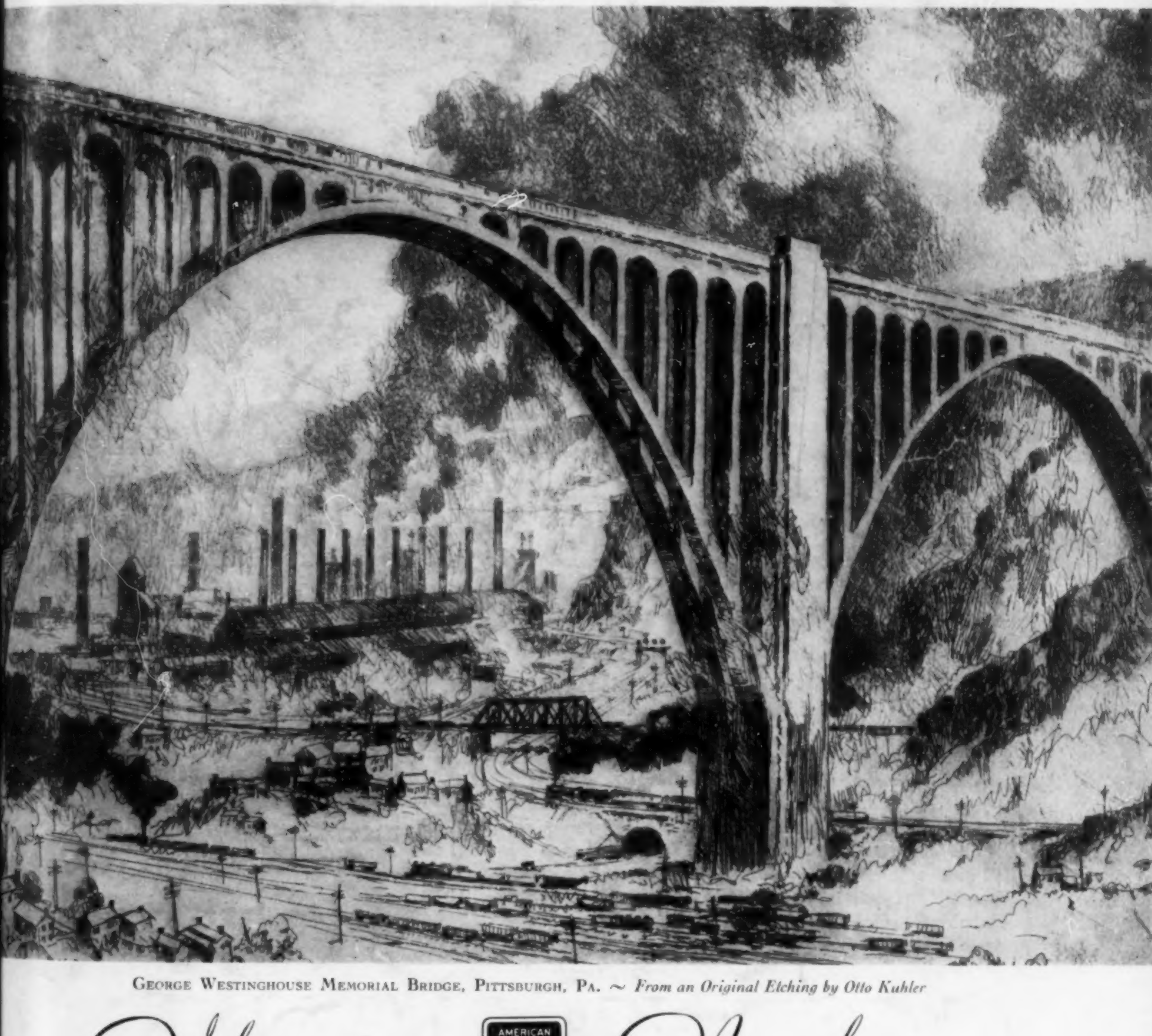

George Westinghouse Memorial Bridge, Pittsburgh, Pa. ~ *From an Original Etching by Otto Kuhler*

Volume 7 — American Society of Civil Engineers Founded 1852 — Number 1

JANUARY 1937

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CAST IRON PIPE

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Among Our Writers

W. V. Buck, after graduating from Kansas State College, was employed for 6 years in municipal construction work. He served as a captain of engineers in the World War. After 1919 he specialized in highway work, acting as state highway engineer of Kansas for 9 years. Since August 1934 he has been senior highway engineer, U. S. Bureau of Public Roads.

K. B. Woods taught civil engineering at Ohio State University from 1930 to 1933. He also served during a part of this period as deputy county surveyor of Darke County, Ohio, and as inspector for the Bureau of Tests, Ohio Highway Department. Since 1934 he has been assistant engineer in charge of soil testing for the bureau.

Walter G. Smith, after graduating in civil engineering at Ohio State University in 1907, spent 6 years on bridge design and construction for railways and municipalities. For the past 23 years he has been connected with the Ohio Highway Department, successively as assistant maintenance engineer, division engineer, and field bridge engineer.

H. S. Mattimore has specialized in highway work for many years, principally as engineer in charge of tests and research, first for the New York Highway Department, and since 1919 for the Pennsylvania Highway Department. He is also active in the technical activities of various highway societies.

Malcolm S. Douglas, after some experience in construction work, entered the teaching field in 1924 at the University of Wisconsin, of which he is a graduate. After a brief engagement at the University of Maine he came to the Case School of Applied Science in 1926, where he has charge of the courses in highways and construction.

O. S. Adams has been connected with the U. S. Coast and Geodetic Survey since 1910. He received a B.S. degree, with honors, from Kenyon College, Gambion, Ohio. Since 1913 he has been engaged in geodetic computation and research. He is the author of various publications on geodetic and cartographic subjects.

L. E. Yoder has been engaged in civil and mining engineering since 1898. At various times he has served as county engineer of Harlan County, Ky., chief engineer and (later) president and manager for coal companies in West Virginia and Kentucky, and division engineer for the Consolidation Coal Company of West Virginia.

U. N. Arthur, after a number of years in railroad work, entered the Pittsburgh Department of Public Works in 1907. He served successively as assistant and principal assistant engineer in the Bureau of Surveys, division engineer in the Bureau of Engineering, and from 1920 until recently as chief engineer of the Department of City Planning.

Joseph White, when heading the statistics and publicity work of the Allegheny County Public Works Department from 1924 to 1932, conducted numerous traffic studies on highways. At present he is traffic engineer of the county. He is also a co-author of *Bridges of Pittsburgh* and numerous other publications.

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NUMBER 1

Development of Highway Structures

New Factors Influence the Design and Construction of Roads and Bridges

AT a session arranged by the Highway Division and the Central Ohio Section and held on October 15, 1936, as a part of the Society's Pittsburgh Meeting, some important new developments in the highway field were discussed. Five of the addresses delivered on that occasion are abstracted here.

In discussing the principles of highway design, Mr. Buck gives limiting values for curves, grades, sight distances, rights of way, and road widths. Next, three recent contributions to highway soil mechanics are described by Mr. Woods—the Proctor test, apparatus for testing shear and consolidation, and the proposed system for classifying soils. In his article on highway bridges in Ohio, Mr. Smith discloses a marked trend toward the use of simple deck types.

Even with modern pavements, maintenance costs are an important consideration. Among the factors affecting the durability of concrete, in pavements and elsewhere, Mr. Mattimore lists the degree of porosity and hardness of aggregates; heat of hydration, rate of hardening, and soundness of cements; denseness of the concrete when placed; and the amount of moisture present when the concrete is being cured. In discussing the weathering of asphalt pavements, Professor Douglas in the closing article shows how much such disintegration depends upon the character and proportion of binder, compressibility of mixture, spacing of contraction joints, and amount of vehicular traffic.

Important Considerations in Highway Design

By W. V. BUCK

MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS

SENIOR HIGHWAY ENGINEER, U. S. DEPARTMENT OF AGRICULTURE, BUREAU OF PUBLIC ROADS, COLUMBUS, OHIO

PROGRESS in engineering design is made possible by the collective efforts of those who are associated with a particular phase of engineering. This is extremely important in highway design, since the uses of the highway have been changing continually and methods of using the materials of construction have been constantly improved. The demand for all-weather surfaces arose early in this century, taxing the ingenuity of the engineer as well as the public treasury. Because of the normal increase in volume of traffic and the tendency towards faster travel, many highways constructed during the last twenty years have become inadequate and obsolete as regards location and design, even though the road surface may still be in a usable condition. Others are in need of complete modernization.

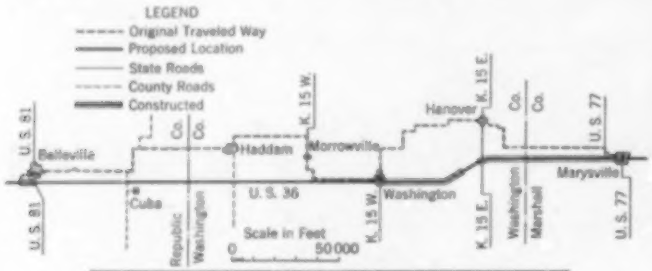
Modernization of highways presents a far more difficult problem than their construction; however, the fundamental problem of providing safe and usable highways remains unchanged. The latitude afforded the designer in open country and in initial construction is absent in the case of highways for thickly populated areas. The costs involved are greater; rights of way are high priced and generally hard to secure (Fig. 1). Therefore, the proper handling of such conditions requires the highest degree of engineering judgment.

With increased traffic and higher operating speeds, accidents to highway traffic have continued to increase until they now reach appalling numbers, and the cost in property damage is astounding. Recent estimates indicate that at least 30 per cent of all traffic fatalities are attributable to faulty location and design. While accidents cannot in the nature of things be prevented by design, much can be done to build safety into highways. Building safety into highways means more than providing paved surfaces properly crowned and drained. Much has been done in providing balanced pavement design and smooth surfaces, and in investigating foundations and subgrades. Roadway beautification, combined with erosion control, has gained impetus in recent years and bids fair to become an integral part of highway design. Design which gives consideration to safety and convenience—it is interesting to note that there is no conflict between these two—has failed to keep pace with some of the other features.

Highways may be divided into three general groups: (1) Highways of national and state importance; (2) highways of country or inter-city importance, and serving as connections between major routes; and (3) highways for local and community service. This paper applies principally to routes of national and state importance. The features of alignment, grades, sight distance, roadway widths, rights of way, and roadside improvement will be considered.

Highways consisting entirely of one long tangent are

impossible. Curves, however, have been looked upon too long as a means of easing a deflection between tangents, rather than as an integral part of highway alignment. Too frequently curves of short radii are wedged between tangents having an abrupt change of direction. Highway alignment must be considered as made up of tangents and horizontal and vertical curves, all of which should be equally safe for travel.



	Old Location	New Location
Length in Miles	70.35	52.73
90° Turns	33 15 of which are in Cities	None
Other Sharp Curves	15 2 of which are in Cities	None
Curves	None	1 @ 1° 45' 1 @ 2° 30'
Total Curvature	None	67° 40'
Saving in Distance, in Miles		17.62

FIG. 1. RIGHTS OF WAY FOR RELOCATION ARE SOMETIMES DIFFICULT TO SECURE

Ten Years of Discussion and Two Reviews by the Kansas Supreme Court Were Necessary in Relocating U. S. Route 36 Between Belleville and Marysville, Kans.

In the selection of horizontal curves, the practice has been to adopt limiting degrees of curvature for different road classifications. These standards were regarded as objectives rather than minimum requirements, and so were varied whenever the acquisition of right of way was difficult. There is now no mystery about the maximum rate of curvature that will permit safe travel at the speeds commonly employed, although data on this subject may have been lacking in the past. The rate of superelevation to compensate for centrifugal force is limited, and a force larger than can be compensated for by superelevation must be taken care of by friction between wheels and road surface.

The rate of turn should be as low as feasible. Curves of $2^1/_2$ deg or less can be readily negotiated when given a reasonable superelevation, and offer good sight distance within the right-of-way lines. Length of curve influences ease of driving, and curves should generally be not less than 800 ft long.

The rate of superelevation varies in different states. It is the general opinion that practical limits for superelevation should not exceed $1^1/_4$ in. per ft of width. Ohio starts superelevation on a 30-min curve by continuing the rate of rise of the crown to the outside of the pavement, using as a minimum 0.01 ft per ft of width, and reaching the maximum rate of 1 in. per ft of width on a 4-deg curve. The use of the spiral is started on the 3-deg curve, and widening is first introduced on the $5^1/_2$-deg curve. Michigan starts superelevation with 0.02 ft per ft of width on the 30-min curve, reaching the maximum rate of 0.1 ft per ft of width on the $2^1/_2$-deg curve. Both states remove the crown on the superelevated section.

Where property is closely built up, at intersections, or where other special speed restrictions exist, the rate of superelevation should be modified. Elsewhere, excess superelevation is of less annoyance to the slow driver than deficient superelevation is to the fast driver. It is time to stop contriving how little superelevation can be used, and to "tip them up."

USE OF SPIRALS INCREASING

Few drivers are capable of judging the safe speed with which to traverse horizontal curves. Many tend to underestimate the degree of curvature and are forced to leave the traffic lane and travel on a flatter curve. On heavily traveled roads this is particularly hazardous, and spiral curves should be employed to minimize the abruptness of the change from tangent to curve. Spiral curves have

RELOCATION OF OHIO ROUTE 39 NEAR MANSFIELD, REPLACING THREE RIGHT-ANGLE TURNS WITH ONE 2°, 30' CURVE

CORRECTION OF ALIGNMENT, NEW BRIDGE, AND RAILROAD GRADE-CROSSING ELIMINATION, U. S. ROUTE 20, MONROEVILLE

TAKING OUT CURVATURE WITH THREE-LANE RECONSTRUCTION ON U. S. ROUTE 40, SHOWN IN FIG. 2

been used in railroad work for many years, but until recently highway designers have abstained from their general use. In addition to facilitating the transition from the normal crowned section to the banked section and encouraging the vehicle to keep in its traffic lane spiral curves help to present an appearance of smooth-flowing alignment. It is safe to predict that the use of such curves will find increasing favor in future.

Vertical curves need all the consideration given to horizontal curves. Long verticals can be used to absorb short breaks and pockets in the grade line. The proper handling of vertical curves has a decided bearing on sight distance (Fig. 2), and in general they should not be superimposed on horizontal curves. Since in actual design it is often impossible to avoid this, however, care should be exercised in the arrangements used.

Alignment at railroad crossings has not always been designed in the best interests of the highway. Too often the highway has been warped to give a "better" crossing of the railroad. Where separation structures are under consideration, the highway has been subjected to short reverse curvature in order to get a shorter crossing and make a cheaper structure, particularly in cases where the railroad has borne part of the cost. The alignment of the highway at a railroad crossing should be correct for the highway, and both grade separations and grade crossings should give the best possible conditions for both utilities.

In designing for horse-drawn and early automotive vehicles, gradient was a most important feature. A highway was useless if the grades could not be readily negotiated. More recently gradients have become of secondary importance, however, and grades of 6 or 7 per cent have but little effect on the speeds of modern vehicles. It is only where grades are long and sustained that speeds are seriously affected.

In the selection of ruling grades, the percentage of heavier vehicles using the highway must be taken into consideration. Where these constitute a small percentage of the total traffic, higher ruling grades may be used. Where heavier vehicles constitute a large percentage of the total, consideration should be given to the cost of providing an additional traffic lane for their use in the direction of movement, as against the cost of grade reduction. Such additional lanes will enable the faster-moving vehicles to pass safely and without delay.

AMPLE SIGHT DISTANCES IMPORTANT

Not all vehicles travel at the same speed; drivers who prefer to go slowly are overtaken and passed by those whose preference is for faster travel. Unless an opportunity is provided to pass with safety, the composite average speed of all vehicles will be reduced to that of the slowest vehicle, thus cutting down traffic capacity. Higher speeds require greater sight distances, which for this reason are of the utmost importance in modern highway design. Sight distances must be sufficient to enable drivers to see and react to conditions ahead.

The tendency in the more progressive states has been to abolish speed limits on the open road, at the same time enforcing the rule that vehicles must be operated in such a way that they may be brought to a stop within the assured clear distance ahead. This places the full responsibility for judging speeds on the vehicle operator, where it rightly belongs. Highway designers may increase sight distances by removing obstructions on the inner sides of horizontal curves (daylighting), and by providing longer vertical curves on grades. For two-lane or four-lane highways on which opposing traffic is not separated by parkway strips, a minimum sight distance of 1,000 ft should be required. When the lanes are separated by parkway strips a shorter sight distance is permissible, as the possibility of accidents is then limited to rear-end collisions.

The three-lane highway has been severely criticized because of the large number of accidents which occur on it. The fault here is not confined altogether to the three-lane construction, but also involves inadequate sight distance. Where the middle lane is used intermittently by traffic proceeding in opposite directions, a much greater sight distance must be available than for two-lane construction, since the potential users of this lane are doubled in number and their aims are conflicting. Sight distances of at least 1,500 ft (or more where practicable) should be provided on all three-lane roads, and in sections where the provision of such sight distances is not possible, consideration should be given to use of four lanes.

Eliminating Two Railroad Crossings by Relocation
A View on U. S. Route 22 East of Washington Court House, Ohio

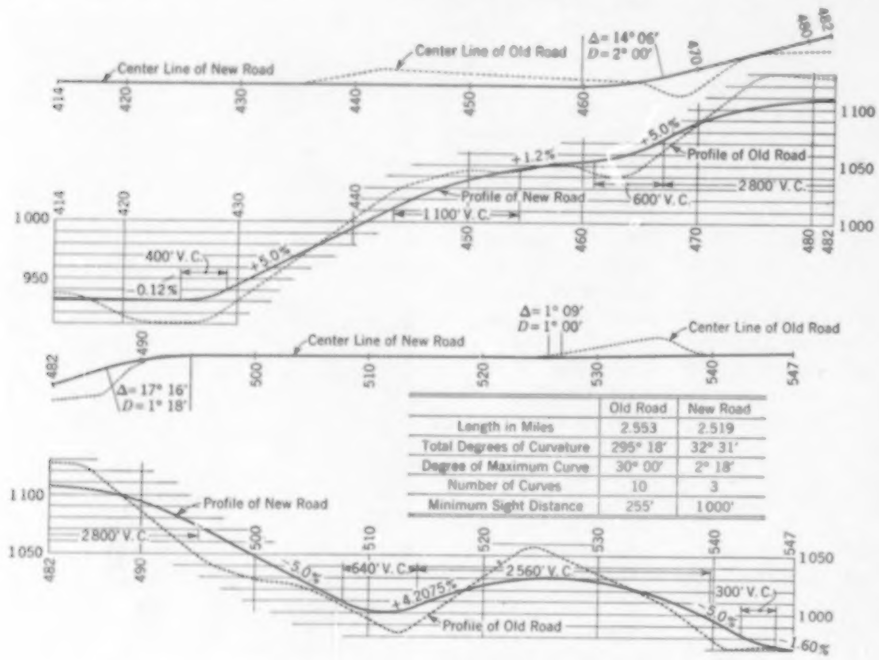
Vertical curves, horizontal curves, and sight distances must all be looked over very carefully when the question of salvaging an existing roadbed or surfacing is under consideration. Very often a salvage job costs more than a new job on improved lines and grades. When existing lines and grades are adequate for present and probable future needs, salvaging should be considered; otherwise lines and grades should be fixed which will be sufficient for present and future traffic.

HIGHWAY WIDTHS MUST BE ADEQUATE FOR THE TYPE OF TRAFFIC UNDER CONSIDERATION

There is a lack of agreement among engineers as to the exact capacity of two-, three-, and four-lane roads. While traffic studies by various agencies have indicated that a two-lane road can accommodate 1,000 vehicles per hour, very little pleasure could be derived from driving in such congestion and at such low speeds. On secondary roads where vehicular traffic is light, one-lane roads find their usefulness. On all others at least two-lane accommodation should be provided. Opinion is divided among engineers as to the desirability of three-lane construction. Some argue that its use permits but a small increase in traffic capacity while causing a greater hazard. Others contend that the use of the disputed lane calls for no greater judgment than the use of the opposing lane in passing on a two-lane road. The three-lane highway has its greatest justification in the vicinity of large cities where the flow of traffic is predominantly in one direction at one time of day and in the opposite at another.

When traffic reaches a volume in excess of that which

can be carried by a two-lane highway, efforts should be made to provide a four-lane highway with opposing lanes separated by parkway strips. The width of the neutral strip does not need to be great; 4 ft is suggested as a minimum. However, this width does not offer sufficient safety for cross traffic, except where traffic lights are used. At intersections the neutral strip should have a width of 30 ft to act as a safety island. Such an arrangement will make it possible for cars to cross the path of traffic moving in one direction as far as the safety island and to complete the crossing when a break in the traffic moving in the opposite direction permits. In the absence of traffic control or grade-separation structures, safety islands offer the safest means for the movement of cross traffic.



	Old Road	New Road
Length in Miles	2.553	2.519
Total Degrees of Curvature	295° 18'	32° 31'
Degree of Maximum Curve	30° 00'	2° 18'
Number of Curves	10	3
Minimum Sight Distance	255'	1000'

FIG. 2. IMPROVING SIGHT DISTANCES BY TAKING OUT CURVATURE
U. S. Route 40 near Linville, in Ohio, Is Being Reconstructed as a Three-Lane Concrete Highway with Lip Curb

When designing a divided roadway so that it can be widened in future (as from four lanes to six lanes) it is suggested that the area for future widening be thrown into the center parkway. The initial pavements should be placed on the outside of the right of way, thereby allowing the drainage ditches and back slopes to be completed and not lost when additional lanes become necessary.

The minimum width of traffic lanes has increased with the increase in rate of travel, as greater clearance is required for safety at higher speeds. While some 8-ft lanes and a large mileage of 9-ft lanes have been constructed in the past, more recently the minimum has been raised to 10 ft. As there is a reluctance among drivers to travel near the edge of the pavement when operating at higher speeds, however, it would seem logical that consideration be given to 11-ft lanes.

WIDTH OF RIGHT OF WAY

Our conception of what constitutes adequate right of way has not kept pace with other developments. The 3-rod and 4-rod widths of right of way are relics of the days of horse-drawn vehicles, and are inadequate for modern highways. Failure to acquire widths adequate for future needs has always resulted in greater ultimate expenditure. Right of way can be purchased more readily at a lower cost at the time of initial construction than at any time in the future. On main highways a right-of-way width of not less than 100 ft is necessary, and it is highly desirable that greater widths than this be secured where there is a possibility of early widening of the surfaced roadway. Where there is an opportunity for particularly effective roadside development, such as the presence of a natural grove, additional widths are justifiable.

Originally a "right of way" included merely sufficient width for the passage of vehicles, but here again we must revise our definition to encompass modern requirements. In addition to the areas of the pavements, shoulders are now required for the use of vehicles which find it necessary to stop, and some provision is also desirable for sidewalks, utility lines, and roadside improvement. Many miles of guard rail could be eliminated by the effective use of right of way. Slopes of three, four, or five to one in fills, and two or three to one in cuts, would provide added sight distance and reduce maintenance costs. The deep ditches which parallel many of our highways are necessitated by the narrowness of our rights of way. These ditches are not only a constant source of danger but in many cases are ineffectual. A much better design utilizes wide, shallow ditches for surface water, and tile underdrains for lowering the ground-water table where necessary.

Provision should be made for turnouts at predetermined points for the stopping of buses, in order that stops on paved areas shall not jeopardize other traffic. Such turnouts require adequate shoulder widths, properly stabilized and surfaced.

Pedestrian traffic also requires increased right of way. In the vicinity of cities and villages and for reasonable distances near public schools, sidewalks must be provided to safeguard those who walk. The walks must be adequately surfaced, for the ordinary individual will use a paved road rather than a loosely graveled walk, despite the risk. Sidewalks, unless protected by curbs, should be located a safe distance from the pavement, preferably beyond the roadway ditch.

ROADSIDE IMPROVEMENTS GAINING GROUND

Highway engineers have often been charged with neglecting the esthetic development of roadsides. This controversy between science and art, which must be settled by intelligent compromise, requires recognition by the highway designer of certain esthetic values. The growing appreciation of natural beauty by the general public is not to be ignored. If a slight change in design will preserve a beautiful view, a specimen tree, or a row of trees, such a change should be considered. Rock cuts can be made more pleasing by stepping back the rock face and planting creeping vegetation.

Roadside improvements require adequate width of right of way. Flat slopes, shallow ditches, and well-rounded cross sections are essential to proper seeding, sodding, and planting. Planting should be of such type and so placed that it will not obstruct maintenance.

Much of the existing natural growth along a proposed

highway can be preserved and developed. Selective cutting and pruning should be resorted to, and all desirable and proper growth should be saved. Plants should be selected to harmonize with adjacent natural growth. It is well to remember that plants native to the area are more likely to survive and are less tempting to those who landscape their property with shrubs from the state highway.

The elimination of all hard lines, the rounding of back slopes, and the drawing out of slopes at the beginning and end of cut sections, make the perspective more pleasing. Construction scars, abandoned roads, and borrow pits, when screened out or covered with vegetation add to the pleasure of travel and minimize distracting influences.

There is a more practical aspect of roadside improvement which can be measured in terms of the maintenance dollar. Shoulders on which there is a good growth of sod are less costly to maintain and emphasize the line of demarcation between the pavement and the shoulder. Flat-fill slopes properly planted eliminate the need for guard rails. Properly planted cut slopes and grassed ditch sections assist in erosion control and are easily maintained.

Vertical raised curbs should be used only as a buffer for parking vehicles and under city conditions where additional width is allowed. The low sloping-lip curb is desirable from a maintenance standpoint on rural highways. A lip curb which is triangular in cross section and rises from the surface of the pavement to a height of $2^1/_2$ or 3 in. in about 9 in. permits wheels to mount and dismount without difficulty and does not reduce the effective driving width.

This type of curb tends to prevent the use and rutting of shoulders by keeping vehicles on the paved surface; it controls erosion of the shoulders and makes possible the growing of grasses on the road shoulder without interference with drainage. It also encourages travel away from the center of the pavement, since the pavement edge is very clearly defined. At night and during rainy weather the driver can keep the car in its proper lane by the feel of the wheel against the curb. In general such curbs should not be used on grades of less than 0.5 per cent, and elsewhere spillways or catch basins should be provided to ensure the quick removal of surface water.

The use of guard rail can be reduced by flattening slopes, but it will still be required in many places. The ideal type of rail is one designed to deflect the vehicle back on the roadway rather than to check or stop it. The rail should be easily visible and should cause a minimum of snow drifting. High guard rails are no longer necessary, because of the lowering of the center of gravity of automobiles. A strong rail is needed, however, on account of modern high speeds.

BY-PASSES INCREASINGLY POPULAR

While the larger and more progressive cities recognize the additional burden which is placed upon their streets whenever heavily traveled highways are routed through their main thoroughfares, some cities still clamor for such routings. Nerve strain and loss of time are always imposed upon the through traveler as well as upon local traffic when a highway passes through a city. In addition, the resulting traffic congestion increases the chances for accidents. It is now generally recognized that cities benefit but little from the additional burden placed upon them, and by-pass routes are being designed for the use of through traffic.

Less attention has been given in the past to the separation of grades at highway intersections than to matters of traffic volume and highway capacity. Many highway intersections in the vicinity of larger cities can be separated now with a minimum of right-of-way difficulty. Five years hence the ability to secure grade separations will be diminished because of increasing right-of-way costs, whereas the need for such separations will be even greater. For this reason, very careful studies should be made to determine the possibility of grade separation wherever a crossing occurs between two highways carrying capacity four-lane traffic. This is especially important in open country where high-speed traffic is being served.

Those charged with the design of roads must give increased consideration to the features of design which have been enumerated, in the light of their increasing importance, in order to build safety into our highways. Highways now being constructed should be adequate for present and for probable future traffic with a minimum of modification. It is quite likely that the motor vehicle will continue to change and improve in the future. Only by continually modifying design and construction practices will it be possible to reduce the rate of obsolescence of our highways and keep pace to some extent with the development of the motor vehicle.

Soil Mechanics in Highway Construction

By K. B. WOODS

JUNIOR AMERICAN SOCIETY OF CIVIL ENGINEERS

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IN the past few years the practical application of soil mechanics has developed very rapidly. Among the recent contributions worthy of careful consideration by the highway engineer, are the following:

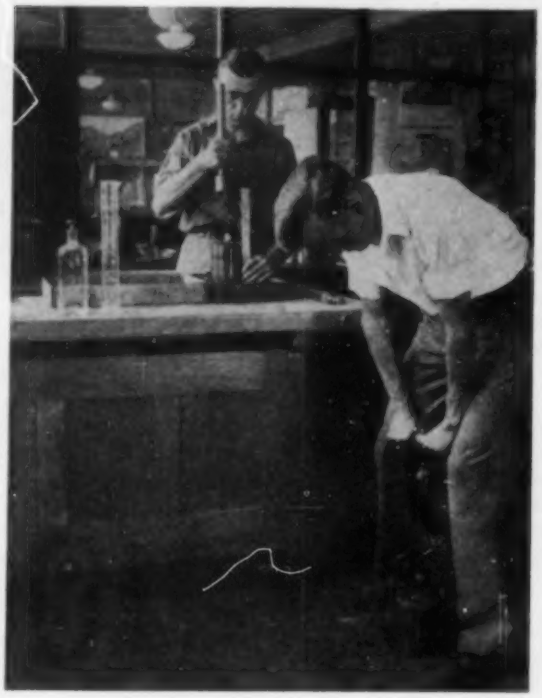
1. The Proctor test for controlling moisture and checking the compaction of embankments.

2. Shear and consolidation apparatus for testing foundation soils in an undisturbed state to obtain the bearing capacity and estimate the rate and magnitude of settlement.

3. Suitable classifications for use in identifying subgrade soils from the standpoint of anticipated performance.

The Ohio State Highway Testing Laboratory has developed a soil department during the past three years, coincident with the advent of the stabilized road, the publication of the subgrade soil report by the U. S. Bureau of Public Roads, and the necessity for making foundation, subgrade, and embankment investigations for the relocation of highways in the Muskingum Water Conservancy District. To carry on the work of the laboratory it has been necessary to train a large number of engineers and to procure a considerable amount of equipment. We are now prepared to make soil tests on samples for subgrades, foundations, embankments, mudjack and stabilization work.

Serious embankment problems have been encountered in highway construction only in comparatively recent years. Embankment difficulties began with the extensive construction of rigid pavements but have become more serious in the past few years with the necessity for minimum grades and greater sight distances. Such design calls for deep cuts and high fills in hilly country and, in many instances, construction of a complete new road and abandonment of the old well-compacted base. Failures due to poor selection of material or to improper field control in placing also occur on small fills in rolling or level country.



PERFORMING THE PROCTOR TEST TO DETERMINE OPTIMUM MOISTURE CONTENT FOR MAXIMUM DENSITY OF SOILS

A test recently developed by R. R. Proctor, field engineer, Los Angeles Bureau of Water Works and Supply (described in *Engineering News-Record*, July through December 1933), has in a sense revolutionized the construction of embankments. It not only provides a means for the control of the moisture content but also presents a method by which compaction can be checked so as to control the number of passes of the roller. Apparently all soils have an ideal or optimum moisture content at which maximum density can be obtained under any given conditions. Any deviation from the optimum will require more compaction to obtain an equal density, and if such deviation is great, particularly on the wet side, an equal density may be difficult to reach.

After the field samples of soil are received at the laboratory, they are crumbled, passed through a No. 4 sieve, and packed in a $^1/_{30}$-cu ft cylinder in three equal layers, each layer receiving 25 blows with a $5^1/_2$-lb rammer dropped from a height of 1 ft. The sample is then weighed, its resistance to penetration measured, and a moisture determination made. This procedure is repeated with increasing percentages of water by dry weight of soil until the wet weight per cubic foot decreases. Both the wet and dry weights are plotted against their respective moisture contents and smooth curves drawn (Fig. 1). The peak of the dry-weight curve represents the maximum density under the compaction conditions, and the moisture content at this point represents the optimum. The resistance to penetration in pounds per square inch is also plotted against the moisture content, and the resulting curve used in the field to check compaction and aid in making moisture determinations.

Field control is comparatively simple. After receipt of the test results on the field sample, the field embankment control kit—containing scales, a $^1/_{30}$-cu ft container, and a $5^1/_2$-lb rammer—is set up and inspection started. A sample of soil, from the borrow pit or from the material being placed in the embankment, is packed in the cylinder in the standard manner and its weight compared with the wet-weight laboratory curve. If the moisture content is below the optimum, water should be added, and if above, the soil should dry before it is rolled.

Compaction is checked by digging a hole with a post-hole auger, weighing the soil so obtained, and then packing it into the $^1/_{30}$-cu ft container in the standard manner to obtain the moisture content. The hole is then filled with dry sand of known loose weight per cubic foot and the volume of the hole determined. Sufficient information is then available to obtain the weight per cubic foot of the dry embankment soil. This weight, divided by the density at the peak of the dry-weight laboratory curve, and multiplied by 100, gives the percentage compaction of the embankment soil, compared with the standard laboratory compaction. Should this density be under the specification requirements, more rolling is required.

SOME LIMITATIONS OF THE PROCTOR TEST

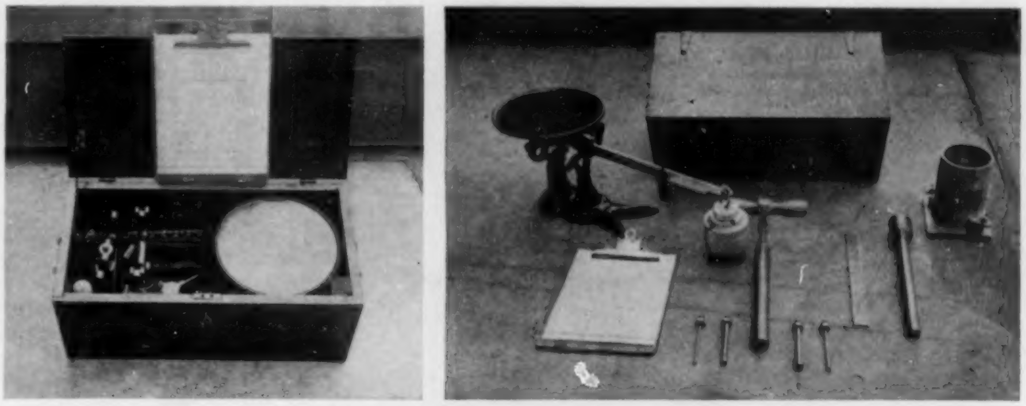
The Proctor test, used in conjunction with a suitable specification, presents a measuring stick for controlling highway embankment construction superior to any other thus far developed. It has several limitations, however, including those imposed by variations in material, presence of granular material or shale, and the personal element unavoidably present in the performance of the test.

Although top soil is comparatively uniform for any particular area, non-uniform material will probably be found when making extensive cuts into the bedrock. In such cases, it is impossible to anticipate the mixture to be placed in the embankment, and as a consequence no curves can be available. Neither can curves be plotted on the job, since the change is usually so rapid that there is not sufficient time to make them.

Granular material makes an excellent embankment if protected against erosion and kept damp, or if there is sufficient fine binding material (silt and clay) to fill the voids. Fine gravels and sands which are not all of one size have a characteristically high maximum density at a low optimum moisture content, and should be placed in a condition near this optimum. Field control of their moisture content is as easily accomplished as for a normal soil by utilizing only the material that passes a No. 4 sieve. However, checking the compaction is in most cases impracticable owing to the difficulty of drilling a smooth hole in such material.

An important point in checking embankment compaction is the presence of material retained on the No. 4 sieve. Since the embankment-control curve is obtained in the laboratory by utilizing only the material which passes this sieve, any appreciable amount of coarser material occurring in the embankment will increase the apparent density because of the higher specific gravity of the stone. This discrepancy can be corrected by substituting soil for such stone in making the compaction tests. In Ohio it has been found that the results of compaction determinations are seldom greatly in error if corrected by deducting one-third the weight of the material retained on the No. 4 sieve from the total weight of the material removed from the compacted embankment.

Shales are quite common in Ohio. They usually appear very stable when encountered in cuts a few feet below the surface, but when exposed to the weather most of them slowly disintegrate and become plastic. Many shale embankments have been constructed which appeared to be relatively stable immediately after completion. Nevertheless, in from one to five years disintegration usually would progress far enough to cause appreciable settlement. If such material is used in a side-hill fill, sloughing and sliding may result. A high percentage of the constituents of a shale will pass a No. 200-mesh sieve after disintegration, and although this percentage will vary through a wide range, it is particularly high for clay shale.



(*a*) Equipment Packed Ready for a Trip (*b*) View of Equipment Ready for Use

Field Kit for Control of Embankment Soils as Adopted by the Ohio State Highway Testing Laboratory

Shale should be placed in embankments in such fashion as to pulverize it as much as possible without allowing the material to lose all its natural moisture content. Sufficient soil fines should be added to completely fill the voids, and sufficient water used to make possible compaction of the embankment at the optimum moisture content. The Proctor test can be used on the soil fines to control the moisture but it is practically useless in checking compaction since the shale particles appear as so much rock unless pulverized.

Although the test is comparatively simple, those applying it must learn to differentiate between silt, clay, and sand, and must become acquainted with some of the fundamental facts about soil behavior. One of the difficulties of training field and laboratory men to check one another is the personal element encountered in compacting the earth in the cylinder. Actual check tests show that an error of several pounds may be introduced into the final results by allowing the rammer to drop from a height appreciably below or above 12 in., by not striking the soil in the cylinder uniformly over the entire area, or by throwing the rammer rather than allowing it to drop. A simple mechanical device designed to reduce time of compaction, and applicable for both laboratory and field use, would be very desirable.

Fig. 1. An Embankment Control Curve for an Ohio Highway Project, Based on the Proctor Procedure

Considerable confusion still exists among engineers as well as contractors concerning the number of passes of the roller necessary to adequately compact a given soil at the optimum moisture content. While this can be checked for each project with the Proctor equipment, the information obtained from projects on various types of soil should be correlated. Information on the weights, types, and respective efficiencies of rollers used on all sorts of embankment soil, placed at optimum and other moisture contents, would also be of value.

OTHER EMBANKMENT SOIL TESTS

The suitability of a given material for use in embankment has usually been judged in the light of the engineer's past experience with the material in question, and side-slope design was largely determined in the same fashion. Shear tests on disturbed samples of proposed embankment soils may in the future eliminate some of the guesswork in determining the critical height of a fill for any given side slope. (See the article by Charles Terzaghi, M. Am. Soc. C.E., in *Public Roads* for December 1929.) But to date this solution appears more academic than practical, on the one hand because of the structural complexity of various soils and their variations in behavior at different moisture contents, and on the other because of the difficulty in distinguishing between internal friction and cohesion in the shear test itself. However, the subject is certainly worthy of further investigation.

While suitability tests are further advanced than shear tests, little attempt has been made to develop adequate specifications. An embankment soil should maintain as nearly as possible a constant volume under various moisture contents. In addition, the material should not deform appreciably under load and should have a relatively high stability when wet. The grain sizes for the soil in question, in connection with other properties as revealed by the well-known Atterburg tests, serve as a source for this information. The U. S. Bureau of Public Roads is the pioneer in such specifications and is to be looked to for future developments.

The presence of appreciable quantities of organic material in embankment and subgrade soils will obviously be detrimental. Information on the quantity of such material which may be permitted is inadequate, and the highway engineer must use his best judgment until satisfactory specifications can be written.

A summary of tests on 368 Ohio embankment soils received in the past year (Table I) will yield some inter-

esting information which might be used as an index to determine the suitability of these soils. Soils having maximum dry weights of from 120 to 135 lb per cu ft, as obtained by the Proctor test, are predominantly in the A-1, A-2, and A-3 ranges of the classification set up by the Bureau of Public Roads. Weights of 110 to 120 lb are obtained largely on A-4 soils, while 100 to 110 lb are likely to be obtained for A-6 or A-7 soils. The lowest maximum weight per cubic foot, 90 to 100 lb, is obtained on the A-5 and A-8 soils, which seem to be very much in the minority as regards the number of samples received. It should also be noted that the latter group is in the questionable range of embankment soils, possessing relatively high liquid limits and low plasticity index numbers. It was also observed in the testing of these lighter soils that organic material or mica was present.

SHEAR AND CONSOLIDATION TEST APPARATUS, OHIO STATE HIGHWAY TESTING LABORATORY

Designed by Glennon Gilboy and R. R. Philippe, Associate Members Am. Soc. C.E.

Another interesting point revealed by this summary of tests is that the average optimum moisture content is always slightly less than the average plastic limit, and that these differences increase as the maximum dry weight per cubic foot increases [Fig. 2 (*a*) and (*b*)].

CLASSIFICATION OF SUBGRADE SOILS

The endeavor to correct subgrade weaknesses in designing highways is still in the experimental stage. Concrete pavements and bases are usually constructed under standard specifications. Provisions are seldom made to increase or decrease the depth, or to strengthen the pavement in one place and economize in another depending upon the subgrade characteristics, since the science has not developed far enough to actually calculate the stability of the different subgrade soils under various weather conditions. However, an abundance of excellent although general information is available which the highway engineer can use as a guide for the present.

In 1931 the Bureau of Public Roads published a series of reports on subgrade soil studies which, correlated with the results from other soil laboratories, constitutes an outstanding contribution to the science of soil mechanics. This report includes a series of recommended tests by which most subgrade soils can be classified in eight major divisions, each representing a soil type having a definite performance record. As a result, soils from proposed subgrades can be tested, classified, and their general performance anticipated before the highway is designed and constructed.

Tests commonly employed in identifying soils include mechanical analysis by sieves and hydrometer, and determinations of the liquid limit, plastic limit, shrinkage limit, and moisture equivalent. The value of these tests has been adequately proved by numerous soil laboratories and they have been adopted by the American Society for Testing Materials and the American Association of State Highway Officials.

Testing and classifying subgrade soils previous to highway construction provides the engineer with information by which many failures can be eliminated. Of course, a thorough understanding of the drainage characteristics and general behavior of the soil under different climatic and loading conditions must be correlated with test information. The profile of the subgrade soil must also be known.

For certain types of soils, such as tight clays, strengthening the subgrade by the use of drained porous insulation courses over it has been practiced rather widely in recent years. In the case of silt soils, particular attention is being paid to the adoption of a high-level profile and to the use of a shallow side ditch with connections under the subgrade opening into deep underdrains or conduits overlaid with a porous backfill. Instead of attempting to drain bad soil subject to frost boils, other technicians recommend excavating it and backfilling with a more suitable material wherever economically possible. The treatment of the subgrade with oils and chemicals has also been used considerably.

Considerable trouble is encountered at times in definitely classifying border-line subgrade soils by the required tests, which makes the task of predicting their performance difficult. Several of the classifications, A-4 in particular, appear to be very broad. Ohio soils are predominantly silts of the A-4 classification, and a wide range in the characteristics of these soils has been noted in the past year. At present it appears feasible to divide the A-4 classification into at least two silt types possessing entirely different characteristics. It is hoped that the Proctor test can be utilized to differentiate between the latter.

TABLE I. SUMMARY OF TEST AVERAGES FOR 368 OHIO EMBANKMENT SOILS

Range in Proctor Dry Weight Maximum Densities Lb per Cu Ft	Number of Samples Tested	Proctor Test: Aver. of Max. Dry Weights Lb per Cu Ft	Proctor Test: Optimum Moisture Content, %	Atterburg Tests: Plasticity Index	Atterburg Tests: Lower Plastic Limit	Atterburg Tests: Lower Liquid Limit	Mechanical Analysis: % Retained on No. 10 Sieve	Mechanical Analysis: Coarse Sand, % Passing No. 10, Ret. on No. 60	Mechanical Analysis: Fine Sand, % Passing No. 60, Ret. on No. 200	Mechanical Analysis: % Passing No. 200 Sieve	Approx. Bur. of Public Roads Classification (For Comparison)
90–95	4	92.9	25.0	16.2	27.6	43.8	2.4	7.3	8.9	81.4	A-5, A-8
95–100	7	97.2	23.2	15.6	26.2	41.8	3.4	6.8	12.9	76.9	A-5, A-8
100–105	47	103.0	19.4	18.9	21.5	40.4	4.0	10.2	11.7	74.1	A-6, A-7
105–110	102	107.9	17.6	16.3	19.8	36.1	6.9	11.2	11.6	70.3	A-6, A-7
110–115	108	112.4	15.4	12.2	18.9	30.7	12.2	13.3	14.5	60.0	A-4
115–120	54	117.5	13.4	10.9	16.9	27.8	15.1	17.6	16.2	51.1	A-4
120–125	26	122.2	11.7	9.7	16.2	25.9	24.2	30.9	11.0	33.9	A-1, A-2, A-3
125–130	15	126.5	10.2	6.8	14.4	21.2	38.0	26.7	10.4	24.9	A-1, A-2, A-3
130–135	3	130.6	10.0	3.2	15.4	18.6	29.1	19.4	14.9	36.6	A-1, A-2, A-3

In a discussion of subgrade, some mention of soil stabilization appears desirable. A well-graded mixture of clay and aggregates with calcium chloride or other suitable chemicals, portland cement, or bituminous materials, when properly chosen and placed in a satisfactory manner, produces an excellent wearing course for secondary roads, giving a relatively smooth surface practically free from dust in dry weather and from unusual rutting in wet weather. Such a mixture serves admirably for use as a subgrade on primary roads, and it has the added advantage of being satisfactory for use as a wearing course for a few months to permit the repair of sub-grade, foundation, and embankment weaknesses.

The soil technician is particularly interested in the selection of the materials to be used on such projects, and must make mechanical analyses of the materials as well as the usual plasticity tests on the binder clay. In most instances the ratio of clay to aggregate must be relatively low when dealing with a highly plastic clay, but relatively high when dealing with a silty clay.

Primary consideration should be given to the use of local aggregate such as bank-run gravel, crusher-run limestone or slag, waste sands, screenings, available road metal, or other suitable materials, since such sources of supply often prove ideal and can usually be obtained at a lower cost than graded specification aggregate. Although most projects to date have been constructed by the "mixed in place" method, much attention is now being centered on central mixing plants.

In designing highways, the treatment of the subgrade soil should be considered in conjunction with the type and design of the wearing course, but should not be attempted without complete information on the subgrade profile.

SOIL PROBLEMS IN MUCK AND PEAT BOGS

In a discussion of soil problems encountered in highway construction, bogs should not be overlooked. Although such problems are not encountered in all parts of the country, they are sometimes very serious. As a rule swamps, muck, or peat deposits occur only in the coastal regions and glacial areas of the north central states. Southwestern Ohio is practically free from such deposits, but the remainder of the state, which was entirely covered by one or more glaciers, has an abundance of them.

The safest and often the cheapest method of dealing with a peat bog area when a highway is proposed is to go around the area. This cannot always be done, but no bog should be traversed without first investigating its extent, both in profile and cross-section, by soundings or borings.

In the past, the most common method of solving such problems has been to keep filling until the correct grade and cross-section were obtained. In such construction the top crust of fibrous organic material is often broken; the embankment drops; and a large heave can be noticed on each side where the muck has been displaced laterally and upward. For such deposits 50- and 75-ft depths are not uncommon, and consequently many thousands of dollars may be spent in filling to a point where stability is reached. In some instances the more stable part of the bog slopes appreciably, thus permitting the filled material to slip laterally about the time stability has apparently been reached.

A more recent method, used successfully by several midwestern states, consists in loading the bog with a part of the proposed fill and shooting the muck from beneath it with dynamite. When performed by a competent and experienced operator, such blasting may give very satisfactory results, even though some settlement must be anticipated because of the loose or uncompacted condition of the fill.

A still more recent method is the attempt to "float" the embankment over the questionable area after the ability of the muck to withstand the proposed load has been determined by shear and consolidation tests. Such a project has apparently been successful in Holland, where the fill was deposited on a mat of reeds placed on the surface of the bog. This method was reported in an

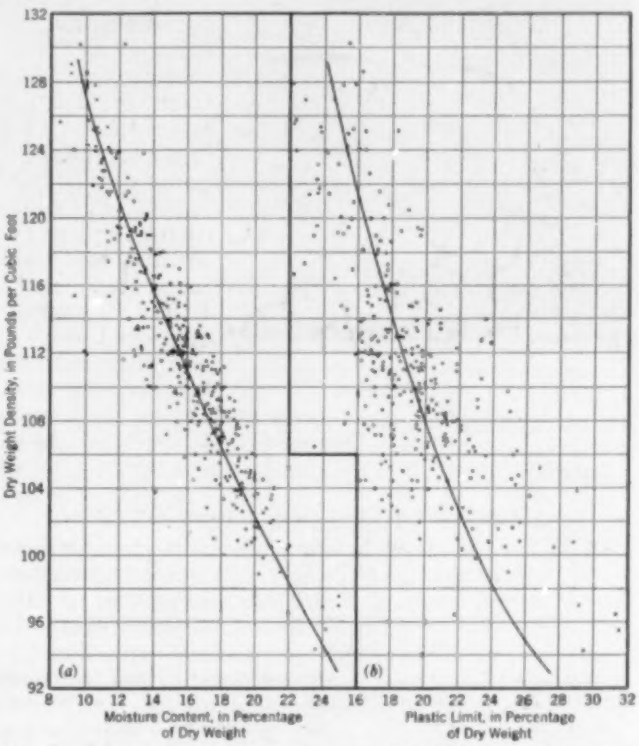


FIG. 2. MOISTURE, PLASTICITY, AND DRY-WEIGHT RELATIONSHIPS FOR 368 OHIO SOILS

(*a*) Proctor Relation of Optimum Moisture to Dry-Weight Density
(*b*) Relation of Plastic Limit to Proctor's Dry-Weight Density

article by J. A. Royer, "Experimental Road for Heavy Traffic on a Very Compressible Soil (Peat-Bog Ground)," in the 1936 *Proceedings of the International Soil Conference*, Vol. 1. Our experience with such procedure is somewhat limited and conclusions can hardly be drawn until our projects have withstood the test of time. In the course of years the character of the supporting material is likely to change; however, little can be lost even if failure should occur due to overstressing the supporting material, since the only other generally recognized method of obtaining stability is breaking the crust and adding material until stability is reached.

In an attempt to limit the stress to an amount somewhat less than the strength of the bog, several large embankments, including a long fill across an extensive peat bog on U. S. Route 42 in Ashland County, Ohio, have been designed in the past year, and are now being completed. It is hoped that the constant checking of these projects will yield valuable information.

When floating is attempted, a minimum amount of fill should be used even at the expense of extensive cuts at each end. The load can be materially decreased by importing material of low specific gravity. A layer of granular material should be used first, to facilitate settlement by providing drainage. For light fills, mats constructed of tree limbs or other suitable materials

should certainly not be overlooked. There are records of some light fills which were successfully constructed in the past by spreading the load over a comparatively large area with tree limbs or logs.

This method of loading plastic soils can be employed more scientifically today in view of the development of consolidation and shear machines for testing such soils in an undisturbed state. Much has been done in this respect for dam foundations, and the highway engineer can profit from these experiences. One of the outstanding factors retarding such development is the slow, tedious, and expensive method of obtaining deep undisturbed samples. Improved ways of sampling and testing, additional experience in interpreting results of tests, and better methods of calculating stresses will do much to take the guesswork out of highway-loading design.

PERFORMING THE LIQUID-LIMIT TEST

MINIMIZING HIGHWAY LANDSLIDES

Highway landslides in Ohio are usually encountered in the hills of the eastern section, where a highway cut nearly always exposes clay, shale, soapstone, or other potential slipping plane. Those sections containing outcrops of the Pennsylvania formation—with its shales, sandstones, limestones, and to a lesser extent but much more detrimental, clays and coal—are the worst areas.

Soil mechanics has a somewhat limited use as yet in the solution of landslide problems. However, landslides in Ohio can usually be attributed to one or more of the following causes:

1. Improper compaction of a high or hillside embankment, leaving excess voids which eventually fill with water. Sloughing or sliding results from the general instability.

2. Using unsuitable material in the embankment, such as fire-clay, shale with insufficient fines, or highly expansive or micaceous soil.

3. Constructing the highway in localities where fire-clay or underclay occurs either beneath the road or above it (as in a cut). Removing the toe of the hillside slope at the fire-clay layer often starts landslides that are checked only after the expenditure of a large amount of money.

4. Constructing the highway in formations of plastic clay or clay shale, which are characteristically unstable.

A thorough knowledge of the characteristics of soil, combined with adequate geological information, is necessary before scientifically attacking such a problem. Our experience with highway landslides in Ohio warrants the following recommended procedure for this area:

1. Identify the formation in question and obtain as accurate a geological log of the landslide as is possible.

2. Supplement this information with adequate drillings and obtain representative samples of the individual layers.

3. Test or identify these samples by using the subgrade classifications of the Bureau of Public Roads, making sure to obtain determinations of natural moisture content.

The test data can be used to classify the samples, and a soil profile and cross-section plotted. This procedure will usually make the cause of the slip apparent. Soil mechanics then becomes helpful in recognizing the drainage characteristics of the various stratifications and in judging the degree of suitability of the materials. Adequate and accurately placed drains may solve one case of sliding while complete excavation of the unstable material may be the solution in another. Piles may remedy the situation occasionally, but are not recommended unless complete information indicates that their use is feasible. Embankment slides caused by the use of unsuitable material may have to be reconstructed, while an improperly constructed embankment containing suitable materials may stabilize itself after it has been properly drained.

In the final analysis, perhaps the best measure for preventing highway landslides is to anticipate them in the preliminary layout either by making light cuts and fills, or, if possible, by going around potential landslide outcrops.

The Development of Highway Bridges in Ohio

By WALTER G. SMITH

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RAPID development in the design and construction of highway structures has taken place in the last decade. Ohio has at times led and at others followed the general trend of this development in types, roadway widths, and load-carrying capacities of highway structures. Standard plans are not followed too generally, but as far as possible each location is given the study necessary to design a structure that will fit the site and give the most value for the money expended.

The development of bridges and highways in Ohio may be traced through the following four stages: (1) The period during which the federal government was building roads, (2) the period during which the federal government was inactive and local subdivisions were in full charge of highways, (3) the period immediately following the creation of the Ohio State Highway Department, and (4) the period following the creation of the federal Bureau of Public Roads and the beginning of cooperation between that bureau and the highway department.

CUMBERLAND ROAD THE FIRST LARGE PROJECT

The National or Cumberland Road was the first great road and bridge project in the state. The last annual report of Casper W. Wever, superintendent of this road northwest of the Ohio River, dated November 18, 1828, was made to Col. Charles Gratiot, chief engineer of the U. S. Army Engineer Corps.

The report, which deals with that section of the road between the Ohio and Muskingum rivers, shows engineering thought, planning, and execution of a very high order. It is especially interesting from the viewpoint of the bridge engineer, when we take into consideration the high quality and extremely low cost of the structures built.

After about 100 years, many of these structures are still in use and in excellent condition, requiring very little maintenance. Most of the replacements have become necessary not on account of failure of the old structures, but to put into effect changes in alignment or grade. A part of the report describing the structures reads as follows:

"The whole quantum of masonry which has been constructed on the line between the Ohio and Muskingum rivers, a distance of 73 miles and 97 poles, is 76,296$^1/_2$ perches, averaging a little over a thousand perches to the mile.

"This masonry is continued in forty-two stone arched bridges, in the abutments of one with an arch of wood of 150-ft chord, and in gothic and square culverts, and detached walls.

"The very expansive quality of the earth, when wet, on the line of the road, rendered it absolutely necessary that the retaining and sustaining walls of the masonry should be of larger dimensions than would have been requisite in the eastern section of the Union. The great height to which the streams rise, and the quantity of drift wood and ice which they float, required an ample provision of vent. Those two causes very largely contributed to swell the amount of masonry greatly beyond what would be necessary on streams of equal width in the eastern part of our country. The inconvenience and certain injury which would result to the community from the stoppage of the mail on one of the most important routes, which in most places where masonry was required, would be the effect of the abruption of a bridge, was deemed an adequate reason, not only for giving full vent to the stream, but also for building the masonry in the most substantial and permanent manner. A belief is entertained that this important object has been accomplished, and that the masonry on this line of road will bear a comparison, in that respect, with that upon any other road within the limits of our Republic."

Of the 42 bridges mentioned, 20 are still satisfactorily serving the purpose for which they were built. This part of the road was let in three contracts, and work started on the first section, embracing 28 miles and 156.6 poles, on July 4, 1825. On this first section, the report states that 36,753 perches of masonry were built at an average cost of \$1.60 per perch. This would be about \$1.75 per cu yd!

For many years after the building of the Cumberland Road the construction of bridges was largely in the province of the counties and cities. The types most commonly used in the early days were covered wooden trusses and stone arches. These structures have given wonderful service. Many of them, from 75 to 100 years old, are today carrying loads far in excess of anything that their designers and builders could have imagined. There are at present on the state highway system 60 covered timber bridges ranging in span from 23 to 200 ft, with clear roadways varying in width from 11 to 22 ft. On all highways throughout the state, there are probably between 400 and 450 bridges of this type.

Stoned-Faced Dublin Bridge Over the Scioto River near Columbus, Ohio
A Description of This Bridge Appeared in Civil Engineering for August 1936

In the latter part of the last century many wrought-iron and steel trusses of various spans were built with masonry substructures of sandstone or limestone. Numbers of these bridges are still in service, and they continue to carry the loads without failure although some of their members are undoubtedly greatly overstressed. The floor systems were in general the weakest parts, and in many cases these have been reinforced and strengthened. The trusses are practically all pin-connected.

The flood of 1913 destroyed many bridges, and these were replaced with concrete and steel structures of various types. This work was practically all done by the counties and cities, as the state highway funds available at that time were very limited. While many of these structures are of adequate strength and roadway width, others present a very serious problem on account of their poor condition.

Steel Arch Over Rocky River, Ohio Route 10
Awarded Prize of the American Institute of Steel Construction as the Most Beautiful Steel Bridge Constructed in 1935

Ohio Department of Highways Organized

The Ohio State Highway Department was organized in 1906, mostly to advise and assist the counties and townships in road-building matters. There was made available to the department the sum of \$440,000 per year, to be divided equally among the 88 counties of the state, with the requirement that the counties provide at least an equal amount. The selection of the roads to be improved was

left largely to the county commissioners or township trustees. Any road in the county could be improved, as no network of roads had been selected to form a state highway system.

In 1911 a Bureau of Bridges was organized within the department, with Clyde T. Morris, M. Am. Soc. C.E., of Ohio State University as its first chief engineer. J. R.

STEEL-BEAM BRIDGE WITH TIMBER SUBSTRUCTURE, FLOOR, AND ORNAMENTAL RAILING, FOR A SUMMER-RESORT DISTRICT

Burkey, the present chief of the bureau, was one of his assistants.

The first bridge designed and built with the aid of state funds was in Pike County over PeePee Creek, on what is now U. S. Route 23. It was built in 1911 and is a through Pratt truss, having a 120-ft 2-in. span from center to center of pins, a clear roadway width of 15 ft 6 in., a 4-in. creosoted-strip floor, and a concrete substructure. The last inspection report shows this structure to be in fair condition except that there is considerable disintegration of the concrete abutments. Although still in use, it is scheduled for early replacement because of the narrow roadway and bad alignment of the approaches.

In 1913, as required by statute, the department laid out a system of inter-county and main market roads, to which the expenditure of state funds was to be limited. This system, with such additions and alterations as have been made since that time, constitutes the present state highway system. On July 1, 1936, it comprised 12,176 miles of roads outside municipalities, out of a total mileage in the state of 85,706. Extensions of state highways through municipalities have a length of 1,975 miles. This year 5,000 miles more are to be added to the system.

In 1914 the highway department received its first appropriations of any size for the construction of highways and bridges. The counties still cooperated with the state, paying at least 50 per cent of the cost of all improvements and furnishing the necessary right of way. Thus they naturally had a large part in selecting the projects. Replacing structures of any great size was the exception rather than the rule, as the demand of the public was for highways.

HIGHWAY DEPARTMENT TAKES OVER STATE SYSTEM

All this was changed in 1928, when a law went into effect making the state responsible for the construction, maintenance, and repair of all roads and structures on the state highway system. County cooperation was discontinued, except in the case of a few of the larger, richer, and more populous counties. The state also was required to secure the necessary right of way.

As the state, until this time, had no responsibility for any of the structures of the system except those it had helped to build, there was no record of the number, type, size, or condition of the structures for which it now had full responsibility. In order to remedy this condition, a survey of all structures on the system was begun in the spring of 1930. As a study of bridge records kept by several of the other states failed to reveal anything we thought would meet our requirements, we proceeded to design and install our own system. This was described in the *Engineering News-Record* of May 17, 1934.

Before we had proceeded very far with the survey, we began to appreciate what a stupendous task the department faced in making the structures safe for traffic. Our bridge record shows that we now have 6,822 bridges of over 10-ft span on the state highway system outside municipalities, and 673 inside municipalities, or a total of 7,495 bridges. Of these, only 416 or 5.54 per cent have spans exceeding 150 ft. There are 1,854 bridges in immediate need of replacement. These are either too weak to safely carry the legal load (H-12 loading), or too narrow to safely take care of two-way traffic (roadways less than 18 ft wide). Of the structures requiring replacement, 131, or 7.07 per cent, are over 150 ft in span length. Thus, it is plainly seen that our principal concern is with bridges of small or moderate span.

A nominal roadway width of 20 ft was used on practically all structures built before 1923, and on most trusses and larger structures for several years after that date. Of course, structures on curves, on roads with heavy traffic, and in municipalities were built with roadways of greater width. After about 1927 all structures were built with roadways of 24 ft or more. Since the standard highway traffic lane has been rather generally established as 10 ft, our usual practice has been to make the clear roadway width equal to 10 times the number of traffic lanes, plus 4 ft.

Most of our structures are designed for an H-15 loading. This differs from the standard loading of the American Association of State Highway Officials in that we use a truck and semi-trailer instead of a simple truck. We assume that 0.2 of the truck weight (specified by the numeral following the H) is concentrated on the front axle and 0.8 on the rear axle. An additional load, equal to 0.6 of the truck load, is assumed on the semi-trailer axle. The distance from front to rear axle of truck is taken as 12 ft, and that from rear truck axle to semi-trailer axle as 12 ft. We believe that this loading more nearly represents the type of heavy vehicle that is now using the highways than the simple truck loading.

The usual types of structures used until about 1930 either as simple single spans or as multiple spans were: Concrete slabs for clear spans of from 10 to 25 ft; steel

A BRICK-FACED CONCRETE-BEAM SUPERSTRUCTURE WITH REINFORCED BRICK SUBSTRUCTURE

Through Steel-Truss Bridge Over the North Fork of the Licking River at Utica, Ohio

A Continuous Steel-Beam Bridge Over the Maumee River in Defiance, Ohio

beams for clear spans of from 15 to 60 ft; concrete beams and girders for clear spans of from 28 to 60 ft; low trusses for spans of from 75 to 115 ft; and high trusses for spans over 115 ft, also spandrel-filled and open-spandrel arches where conditions were favorable.

Many of the through concrete-girder spans were built with roadways of 20 ft or less. These now cause considerable concern as the superstructures have no salvage value in case the structure must be widened. The last bridges of this type were built in 1928–1929. Quite a few through concrete-arch structures of from 60- to 120-ft span with roadways of from 18 to 24 ft were built from 1919 to 1929. This type was discontinued for the same reason as the through girders.

MOST NEW BRIDGES OF THE DECK TYPE

In selecting the type of bridge now being used, we were greatly influenced by the desire to build structures that can be widened if traffic increases to such an extent as to render it advisable to do so. This limits us largely to deck-type structures.

The steel mills in 1928 started rolling 33- and 36-in. beams. This immediately made [illegible] the use of simple beam structures with spans u[illegible] length, while with the 30-in. beam, $62^1/_2$ f[illegible]ly about the maximum. Until the advent o[illegible]ger beams the steel beam had not been able to [illegible] advantageously with concrete-beam structures, which can be built economically with a span up to 60 ft. In 1929 we were able to secure these large beams with a camber put in at the mill. That year we built a simple span of 63 ft using 30-in., 200-lb I-beams. A camber of $3^1/_2$ in. was specified, but when the mills attempted to camber the beams this amount it caused a buckling of the web, and the camber was reduced to approximately 2 in.

With the advent of cambered beams, the advantages of building multi-span continuous structures of this type were at once apparent. Spans might be longer; fewer and lighter piers might be used, causing less obstruction to the streams; and fewer expansion joints would be required. A structure of this type has a somewhat greater depth than the floor system for a truss of a through girder, but it has the great advantage of being easier and more economical to widen if that should become necessary. It also generally permits better vision and is more attractive. However, since the spans are shorter than those generally used for trusses or through girders, the additional piers required might be a decided disadvantage in a stream carrying a large amount of drift or ice.

Two kinds of floor framing are used. In one type all longitudinal beams are main members, and in the other there is a system of main longitudinal beams alternated with intermediate longitudinal beams supported on transverse floorbeams. The cost is approximately the same for either arrangement.

The first bridge of the continuous steel-beam type, designed and built in 1930, consisted of five 70-ft spans on a 60-deg skew. A through type would have been very unsightly in this location, in flat, open country, but the continuous beam proved very pleasing. In larger spans of this type, using built-up members instead of simple rolled beams, a pleasing arch effect may be secured by haunching the bottom flange of the girders. This is economical in the continuous-span structure, as the negative moment at the intermediate support exceeds the positive moment at the center of the span.

The abutments for our structures are usually of types that will readily lend themselves to widening. In general they have straight wings, continuous with the breast wall. Porous backfill is used behind all abutments and retaining walls.

Until very recently we generally used a separate wearing course consisting of concrete, brick, or other materials. Water would get under this wearing surface, especially if it had been constructed on a sand cushion, and would cause serious disintegration of the concrete structure at the curb line. We are now building quite a number of bridges with monolithic wearing courses. Where a separate wearing course is used, drainage is provided at frequent intervals through the floor slab along the curb line. We are also using a mastic or waterproof cushion. While our general specifications do not require concrete to be vibrated, vibration is permitted in all cases and is required in some.

Before a structure is designed, soundings are taken to determine foundation conditions. The results have amply justified the cost of this work. The methods used have been described in full in Bulletin 90 of the Ohio Experiment Station.

TIMBER BRIDGE HAS MANY USES

A low-cost type of bridge, developed and used in the winter bridge program of 1931–1932, has been used a great deal since that time on our secondary roads. It consists of a creosoted pile-and-timber substructure, with steel or creosoted-timber stringers, a creosoted-strip floor, and untreated timber rail. Owing to its large salvage value as compared with other types, it lends itself admirably to locations which may be temporary. Several bridges using this type of substructure and stringers, but with a concrete floor, have been designed and placed under contract in 1936.

We also use a modification of this type on secondary

A TYPICAL GRADE-SEPARATION STRUCTURE
Roadway Width, 40 Ft; Vertical Clearance, 14 Ft 2 In.

roads or roads with very light traffic, and in locations where it is necessary to build a safe structure but where it is practically certain that the road will be relocated in the near future. This is a lighter bridge, designed for H-12 loading with a 50 per cent increase in the allowable unit stresses. Either treated or untreated timber is used, depending on conditions. Roadways are usually 20 ft wide.

We give considerable study to the architectural treatment of our structures. In some locations, such as metropolitan park areas, the esthetics of a structure influence its design to a great extent. In the case of railroad grade-elimination structures, we design those of the overhead highway type, whereas the highway-underpass bridges (carrying railroad traffic) are designed by the railroad bridge engineers. However, we have recently begun to interest ourselves considerably in the architectural treatment of the underpass structures since their appearance is more noticeable to motorists than that of any other type. Our suggestions, made to the railroad companies by means of sketches of elevations, have met with hearty cooperation in nearly all cases.

We believe that we are now building structures of a type that will give long and satisfactory service at a reasonable cost, and that in case of changed conditions requiring wider roadways, relocations, or other modifications, a large part of the value of our structures can be salvaged.

The Durability of Concrete

By H. S. MATTIMORE
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ENGINEER OF TESTS, PENNSYLVANIA STATE HIGHWAY DEPARTMENT, HARRISBURG, PA.

CONCRETE as a building unit has a broad use in many construction fields because of its flexibility. Such variety of use gives rise to many different conditions of exposure, which thus form the most important element in determining durability. Aggregates, [illegible]nt water, mixing, placing, and curing protection are [illegible]actors. Durability may be defined as the power to [illegible]sist agents or influences which cause change or decay. When broadly interpreted it varies with the structure involved. For instance, slight surface scale would be detrimental to the appearance of decorative concrete, although it would not be considered serious in most structures. In some cases other surface defects, such as checks and cracks, may exist and yet not be detrimental. Durability in the normal structure is related to serviceability—in other words, a durable structure is one that functions in accordance with the design.

AGGREGATES SHOULD BE TESTED AND INSPECTED

In the case of concrete structures subject to average exposure, good specifications together with efficient supervision will provide adequate control for the aggregates, but in the case of concrete to be used under conditions of severe or special service, provision should be made to secure aggregates that will furnish the maximum resistance to destructive agents. For instance, porosity or absorption is often a factor in aggregates to be used in dams, piers, or other structures subject to the action of water alone or of water and frost. Other requirements worth observing in special cases are fire resistance and hardness to resist abrasive action. In severe conditions of freezing and thawing the mineral components of the aggregates might well be a factor.

One case of concrete disintegration has been definitely traced to the use of unsound coarse aggregate. Fortunately this was detected before much concrete had been placed, but comparison of the concrete having sound aggregate with that having unsound indicated a very definite effect. Disintegration attributable to volume change of unsound coarse aggregate and similar causes has led to a revival of the sodium-sulfate soundness test for coarse aggregate. This same test is also gradually being adopted for the purpose of determining the soundness of fine aggregate. It is especially pertinent for aggregates used in concrete subject to sulfate action or other conditions likely to produce volume changes.

RECENT RESEARCH IN SPECIAL CEMENTS

Portland cement, a mixture having a complex nature, has been a subject of study for many years, both from the chemical and the physical standpoint. It is only recently, however, that definite information has been published relative to calculating the composition of the compound by chemical analysis. This has led to more detailed studies of the cement, and to specifications definitely limiting the percentage of given substances. If based on well-planned research studies, related to the service value of the structure in which such cement is to be used, specifications of this type will yield a product which will ensure more satisfactory and durable concrete for special purposes. These special cements are not improved products for use in all concrete, and should not therefore be specified for work where ordinary portland cement would be more satisfactory. For instance, cement producing low heat during hydration will probably make possible a more permanent construction in a massive structure like Boulder Dam, but this does not necessarily mean that such cement is superior for use in thin pavement slabs or retaining walls. In fact, slow-hardening and other qualities observed in this modified product may prove unsuitable for concrete in thin sections where heat accumulation during hydration is not a factor.

It is interesting to observe the present trend of con-

crete research. Studies of aggregates, methods of proportioning, ratios of water and cement, and general mixing are still under way, but attention seems to be centered on studies of cements. Published methods for calculating the proper proportioning of the compounds present in cement have been generally accepted and have inspired research projects on concrete durability as affected by cements of different compositions. A research of this sort is a lengthy matter and no results based on comprehensive tests have so far been published.

In the past, the factor of freezing and thawing was usually associated mainly with unstable aggregates or permeable or porous concrete. But as recent research has shown that volume change must also be given consideration in the resulting disintegration, denseness of concrete is evidently not the whole answer. It has also been found that cements of different compositions show differences in volume changes, indicating that this factor should receive attention when resistance to freezing and thawing is to be considered.

Sea water, mine-water drainage, and other liquids containing sulfates which may subject concrete to acid action are a cause of disintegration. It is recognized that the use of ordinary portland cement will not in all cases make concrete durable enough to resist such exposures, and special products termed "modified cements" are being manufactured at the present time for this purpose.

Sulfate-resisting or medium-heat cement is produced by limiting the tri-calcium alumina (C_3A) compound. One of the tests originally devised for this purpose was the sodium-sulfate test, in which thin panels of neat cement are suspended in a 10 per cent solution of sodium sulfate. To successfully meet this test the specimens must remain in a normal condition without warping or disintegration for a given period. Most cements of low C_3A successfully pass this test, but in many cases the same cement gave comparatively poor results under freezing and thawing tests.

In producing cement with a low C_3A content it has been found necessary in some cases to add additional iron, thereby increasing the tetra-calcium alumina ferrate content (C_4AF). Very little has been published on the performance of cement of this type when used in concrete exposed to severe conditions, but some preliminary laboratory research showed that this product gave low resistance in freezing and thawing tests. No definite conclusions are available as to whether this might be due to the additional iron, whether such cements must be more carefully burned, or whether some balance must be maintained between the tetra-calcium alumina ferrate

EXAMPLE OF EFFECT OF USING UNSOUND COARSE AGGREGATE
Scaling Due to Disintegration of Limestone Aggregate in Retaining Wall, Green County, Pa.

and other compounds to produce a product more resistant to severe exposure.

INTEREST REVIVES IN AUTO-CLAVE TEST

Research on volume change of cement and concrete has revived interest in the Auto-clave soundness test.

EXPERIMENTAL HEADWALLS BUILT IN MCKEAN COUNTY, PA., TO STUDY CONCRETE DURABILITY UNDER SEVERE EXPOSURE

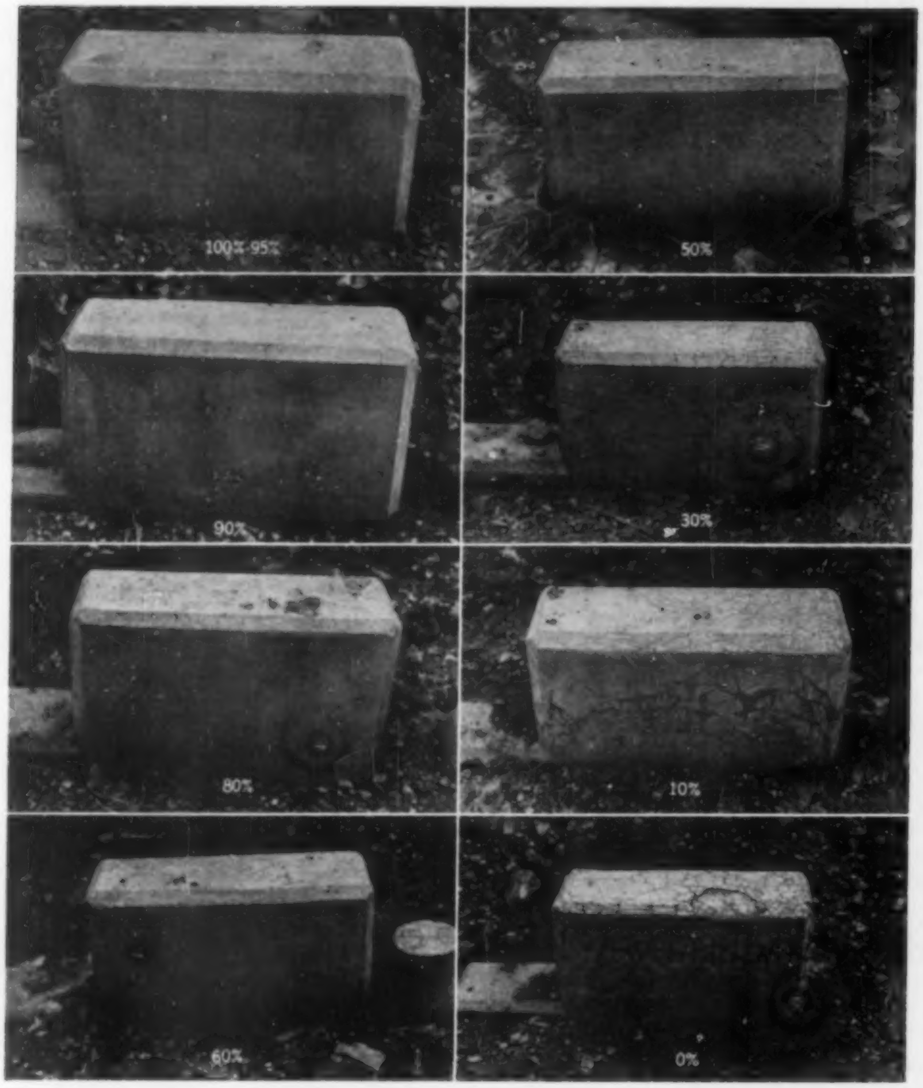
Articles pertaining to this test were published in 1912, 1913, and 1914 in the *Proceedings of the American Society for Testing Materials*, but interest in this subject became dormant after a time and no general consideration was given to use of the test until the past few years. The test is much more severe than the standard soundness test, and some of the investigators who are using it seem to think that it will detect underburned cement. If so, it will fill a great need in the field of cement testing, because underburning may be the basic cause of some of the volume changes noted in certain cements.

In all these researches it has been noted for a number of years that some of the cements which give successful results in practice also stand up well when subjected to freezing and thawing tests. Therefore, conclusions should not be drawn too quickly, and cements modified by limiting the amount of certain compounds should be used only for special purposes until more information is obtained.

There are indications that cement specifications in future will call for several cements of different types for use under different conditions, and will probably include chemical limitations either on compounds or oxides. But it should be remembered that in changing the nature of cement, proper mixing and burning must receive primary consideration. Failure to observe this rule may give rise to additional defects.

Improper mixing and placing of concrete have led to a product lacking in durability. While the operation of mixing concrete has been subject to some study and has resulted in more efficient mixing equipment, sufficient study has never been given to this phase of concrete making. The procedure seems to be to accept modern mixers as furnished and to try to regulate the mixing time so as to produce a uniform product. Regulating the water content of concrete mixes has proved an important factor in producing a more uniform product. Until the advent of vibrators, however, the consistency of concrete was determined to a large extent by placing requirements. This situation is now reversed, in that a much drier mix can be placed by the use of vibrators that can be handled by the modern mixer.

The placing of concrete with vibrators has led to the use of a drier mix and probably to a denser product. Internal vibration when used under proper supervision has been advantageous in placing concrete in heavily



CONDITION OF EXPERIMENTAL HEADWALLS AFTER 4½ YEARS OF SEVERE EXPOSURE
On the Basis of Their Various Conditions, the Walls Were Given Structural Ratings as Indicated in Each Case

reinforced sections. Proper supervision must be maintained to avoid over-vibration with resulting segregation.

Carelessness in using wet concrete, causing laitance and preventing the proper bond between concrete placed on different days, has been a factor contributing to concrete disintegration. In fact, examination of older concrete structures often indicates that while the body of the concrete is intact, the construction joints show signs of disintegration.

MOISTURE OF PRIME IMPORTANCE IN CURING

Proper curing and protection of concrete is still a construction problem, although there has been considerable discussion on this subject and many instructions have been published. Usually curing and protection are better regulated in the hot summer months than at other times of the year. It seems to be common knowledge among constructors that hot weather has a tendency to dry out the concrete mass, resulting in a checked surface not properly hydrated and likely to be of low strength; but it does not seem to be generally recognized that the same condition may result when unhardened concrete is exposed to wind action regardless of temperature.

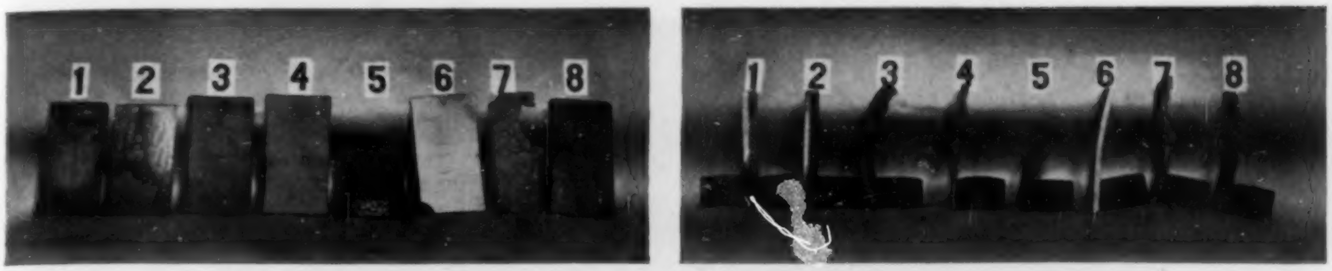
The theories of hardening of concrete are that cement hydrates and hardens in the presence of water, that a certain amount of water is absolutely essential for this action, and that this moisture is required regardless of the season of the year. From this standpoint, the use of dry heat for protection in cold weather is a dangerous procedure unless the concrete surfaces are covered with saturated burlap, cotton mats, or other suitable material.

The curing methods used include direct application of water either by spray, saturated coverings, or ponding; sealing of exposed surfaces to prevent the evaporation of contained water; and the use of a deliquescent salt, either in the form of an admixture or as a surface application. Naturally, direct application of moisture is the most positive of these methods, but on some structures it is inconvenient or difficult to control. Surface sealing, used on many different types of structures, is based on the theory that the moisture contained in the concrete is sufficient for proper hydration. In highway work a highly absorbent subgrade might be detrimental to this type of curing, as additional water cannot be added. The efficacy of a deliquescent salt drawing moisture from the atmosphere is affected by the percentage of humidity present. The critical point is about 40 per cent.

The use of concrete under conditions of extreme exposure such as freezing and thawing, or where exposed to the action of sulfates, acids, and other substances, may really be an abuse. All materials have limitations, and it may be observed that under certain conditions of exposure even some of the natural building stones are likely to show scale and disintegration. Those who sincerely advocate the use of concrete could not hope to have this product of a more durable nature than natural building stone. If concrete is the most convenient product to use for structures subject to such exposures, long life cannot always be expected, but even so a careful selection of aggregates, cement, and water should give a better product.

The points that might be stressed relative to the production of more durable concrete are a careful selection of aggregates, cements, and water. This does not mean making merely occasional tests, but regular ones accompanied by careful inspection. Very few natural products are uniform; therefore aggregates should be subject to close and frequent inspection.

Mixing water should be analyzed and tested, and during the course of the work care should be taken in certain localities to see that no new source of pollution occurs. At times, in drought periods, streams that are subject to pollution may reach the stage where their waters are unsuitable for use in concrete. Cement as made today is carefully proportioned and usually well manufactured, but it should nevertheless be carefully



Neat Cement Specimens After Suspension in a 10 Per Cent Solution of Sodium Sulfate
Left, Front View of Panels, Showing Disintegration; Right, Side View of Panels, Showing Warping

tested. In regard to special uses for severe exposures, it may be advisable to select cements which experience has shown will be efficient. This does not necessarily mean new products, since some of the older products have proved efficient for such purposes.

PROPER FIELD INSPECTION ESSENTIAL

The mixing, placing, and curing of concrete is a procedure over which the designing engineer and the laboratory technologist have little or no control. The best of products may be specified and used, and concrete structures may still be ruined with careless field inspection. Inspection of concrete is an operation that should not be left in the hands of incompetent men. No man can consider himself a competent inspector until he knows the full theory of mixing, placing, curing, and protection of concrete. It is not sufficient to train men to carry on certain operations; they should also know the reasons for what they are doing so as to be able to take care of unusual conditions which may arise during the progress of the work. As stated before, special precautions must be taken in the curing of concrete during cold weather. The use of salamanders and other dry heating devices is not objectionable provided the concrete has sufficient moisture. What concrete requires for proper curing in cold weather is not dry heated air but moist heated air.

It has been found during many years of experience that the difference between durable and non-durable concrete rests largely on materials and proper field inspection. Usually such operations as testing of materials are well performed, especially in large organizations. These operations are standardized and can proceed more or less along routine lines, but proper field inspection is very difficult to standardize and must be supervised by persons with good judgment and knowledge of the product that they are handling.

Weathering of Asphalt Pavements

By Malcolm S. Douglas

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In recent years the problem of weathering of asphalt roads has been more apparent than formerly, due in large measure to the lack of maintenance resulting from the diversion to other public expenditures of funds which normally would have been used for this purpose. Asphalt, like all other materials, weathers or disintegrates in time, being affected primarily by heat, cold, water, and the action of light. No one authority has made a complete analysis of the causes of asphalt pavement disintegration, and the information in this paper is taken from many sources as well as from field observations and experiments by the author.

Asphalt is a bitumen consisting mainly of hydrocarbons and small quantities of their sulfur, oxygen, and nitrogen derivatives, all of which are soluble in carbon disulfide. So far investigation of these substances has resulted only in establishing the existence of groups of compounds of high molecular weight, and the presence and proportion of combined oxygen, sulfur, and nitrogen. The hydrocarbons in which the adjacent carbon atoms are joined by one valence are said to be saturated. These are quite stable and not apt to undergo chemical changes. The unsaturated hydrocarbons are those in which the adjacent carbon atoms are joined by two or three valences. The latter group is less stable, as the extra bonds tend to form new saturated molecules.

The volatile constituents of the bitumen are gradually evaporated on exposure to atmospheric conditions, the rate of this evaporation being approximately proportional to the temperature. Volatilization at elevated temperatures is regarded as a test of what will take place when bitumen is exposed to the sun and atmosphere over a long period of time.

Oxidation, like evaporation, takes place on exposure to air and is more pronounced at high than low temperatures. It may take place by oxygen uniting with hydrocarbon, by oxygen uniting with hydrogen to form water, or by oxygen uniting with carbon to form carbon dioxide. The action of oxidation goes hand in hand with carbonization, in which certain bitumens, in the presence of oxygen, form water and free carbon. Carbonization may take place either in direct sunlight or when the bitumen is overheated.

When a bitumen has been removed from its source it undergoes a change in internal molecular arrangement. Trinidad asphalt hardens rapidly on the surface of the lake, and residual bitumens undergo considerable change after enduring the heat necessary for production. This condensation, which is somewhat comparable to the setting of portland cement, is termed polymerization. It occurs to a greater extent on the surface and at small distances below the surface. P. E. Spielmann in his book, *Bituminous Substances* (London, 1925), makes the suggestion that the surface-hardening phenomenon is due not only to oxidation, action of light, and polymerization, but also to the presence of paraffin wax, and

that the true polymerization occurs below the surface.

All bitumens are affected by moisture, which may either be absorbed or may gradually wash out the soluble constituents. The oxidized substances have a greater affinity for moisture than the original hydrocarbons; consequently the leaching process is intensified as oxidation progresses. Among other effects of weather upon the physical and chemical characteristics of bitumens are a lightening of the color, a dulling of surface finish, decreased ductility and tensile strength, decreased adhesiveness, increased hardness, and an increase in both free and fixed carbon.

A TYPICAL EXAMPLE OF DISINTEGRATION OF SHEET ASPHALT

ACCELERATED TESTS

An accelerated weathering test, as developed by the Bureau of Standards, consists of exposing the bituminous substance, in the form of thin films placed on aluminum plates, to the action of a carbon-arc light, water, and refrigeration. The cycle used was as follows: light, 18 hours; water spray, 3 hours; and refrigeration, three times a week for a period of one hour. According to P. H. Walker and E. F. Hickson, "Accelerated Test of Organic Protective Coatings" (Bureau of Standards *Journal of Research*, Vol. 1, 1, 1928), these tests indicate that "poor weather-resisting bitumens will fail within 50 days and that satisfactory bitumens should withstand the accelerated test from 50 to 80 days without showing signs of cracking through the coating to the metal panel."

Tests of the Case School of Applied Science using 50-penetration asphalts were carried out in the same manner. Other investigators have studied the effects of weathering asphalts by placing the samples under a plate glass, and allowing the sun's rays to heat the specimens and produce the destructive effect of light. These tests, as described by R. H. Lewis and W. O'B. Hellman ("A Study of Some Liquid Asphaltic Materials of the Slow Curing Type," *Public Roads*, June 1934), indicated the following:

"1. The high-gravity materials and their residues which were studied are more susceptible to temperature changes than the low-gravity materials and their residues.

"2. Changes in inherent characteristics which may be attributed to chemical action, namely, oxidation, polymerization, and carbonization, take place to the greatest extent under exposure to the sun and least during distillation.

"3. Carbonization does not occur during laboratory heat tests or outdoor exposure, as made in this study, in those materials which originally have little or no matter insoluble in carbon tetrachloride. It does occur in materials which initially have some material insoluble in carbon disulfide and appreciable amounts insoluble in carbon tetrachloride. Specifications calling for high solubility in carbon dissulfide and carbon tetrachloride will be advantageous in minimizing the possibilities of carbonization playing a part in the weathering of the materials in road service."

The question of the relative desirability of native, steam-refined, and blown asphalts is still unsolved.

There appears to be general agreement that lake asphalt is the most desirable, but the differential in price between lake asphalt and the manufactured product practically prohibits use of the former.

Comparing blown asphalt and residual asphalt, Herbert Abraham in his book, *Asphalts and Allied Substances* (New York, 1929), states that" blown asphalts, due to their greater softness and correspondingly large proportion of 'life-giving' constituents, are better weather-resistants than residual asphalts... It is a mooted question whether the native asphalts or the blown asphalts excel in weather resisting properties. . ."

On the other hand, W. J. Emmons, M. Am. Soc. C.E., in his paper on "Stability Experiments on Asphaltic Paving Mixtures" (*Public Roads*, January 1935), observed that disintegration under traffic occurred in sections of experimental pavements containing blown asphalt, and that this tendency was confined entirely to such mixtures. The Mexican steam-refined asphalts used by Mr. Emmons had a ductility ranging from 77 to 100 plus. In contrast to this, the Mexican blown asphalts had ductilities ranging from 13.5 to 65. The ductility of an asphalt primarily indicates its adhesiveness. The blown asphalts, having a lower ductility than the steam-refined asphalts, would be expected to have slower adhesiveness and consequently a greater tendency to disintegrate under traffic.

PRECAUTIONS IN MIXING

Considerable care should be taken in controlling the temperature of hot asphaltic mixtures. Asphalts are

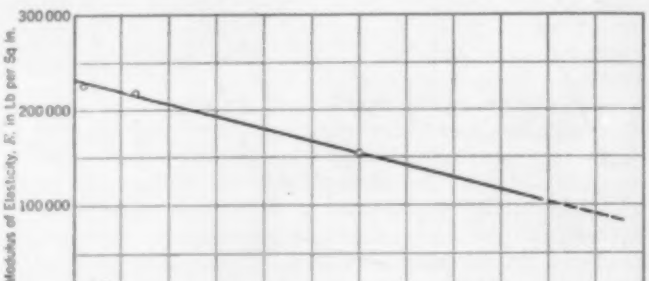


FIG. 1. CORRELATION OF MODULUS OF ELASTICITY, MODULUS OF RUPTURE, AND TEMPERATURE FOR SHEET ASPHALT

(*a*) Relation of the Modulus of Elasticity to Temperature

(*b*) Comparison of Temperature Stress with the Modulus of Rupture

Cracking Due to Lack of Traffic — Scaling Due to Poorly Graded Mixtures — Cracking Caused by Low Temperatures

THREE WAYS IN WHICH SHEET-ASPHALT PAVEMENTS DISINTEGRATE

readily oxidized when exposed in thin films to the air at temperatures as low as 300 F. There is a similarity between the reaction at the mixer and that obtained through the blowing process of refining. The bitumen in the mixer is brought into intimate contact with the oxygen of the air by the exposure of thin films of asphalt with a large excess of air at temperatures slightly lower than those required for oxidation. In the air-blowing process, the contact is with a relatively small excess of air for a greater length of time and at temperatures slightly higher than those required for oxidation.

John H. Bateman, M. Am. Soc. C.E., and Charles Delp ("The Recovery and Examination of the Asphalt in Asphaltic Paving Mixtures," *Proceedings of the American Society for Testing Materials*, 1927) found that the physical characteristics of asphalts recovered from mixtures with mineral aggregates indicated that oxidation had taken place in the mixing process. The specific gravity, flash point, and fire point were slightly increased; the softening point was materially increased; penetration at all temperatures was materially lowered, with extremes drawn more closely together; and the ductility of the two harder asphalts was greatly reduced.

In accordance with this, the Ohio Department of Highways has developed the following specification dated November 1, 1935, to control oxidation at the mixer:

"Preparation of Asphalt Cement. The asphalt cement shall be delivered to the asphalt bucket at a temperature between 250 F and 350 F. No asphalt shall be used while foaming. All asphalt cement heated beyond 375 F either before or during mixing with any of the aggregates shall be rejected.

"Preparation of Mixtures. All the aggregates shall be mixed dry for a period of 15 seconds; the asphalt cement shall then be added in an evenly spread sheet over the full length of the mixer box. The mixing shall be continued for a period of 30 to 45 seconds for binder; for sheet asphalt wearing course it shall be continued for one minute. The total time of mixing shall be the interval of time between the opening of the weigh-box gate and the opening of the mixer gate. The number of batches produced in one hour from one mixer shall not exceed 60."

WAYS IN WHICH WEATHERING TAKES PLACE

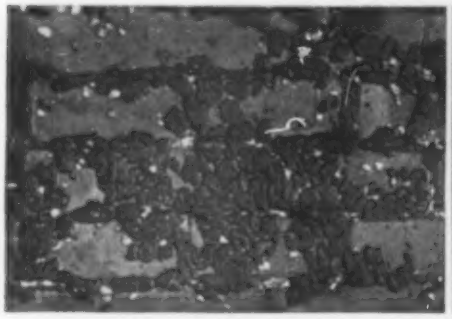
The weathering of asphaltic pavements is a measure of their permanency. It is affected by disintegration of the pavement, formation of holes, raveling of the surface, formation of cracks, and failure due to upheaving of the base. The heaving of the sub-base produced by poor drainage or by frost action creates a type of failure which should not be attributed to the asphalt pavement and therefore will not be discussed in this paper. Cracks may appear in the surface of the pavement due to the contraction of the concrete base. These cracks usually extend transversely across the pavement and manifest themselves either by a sharp break in the asphalt surface or by an irregular tear caused by the stretching of the surface across the opening in the base. This type of crack can be somewhat controlled by the design of the concrete foundation. Experiments carried on by the Rhode Island Board of Public Works, as reported in the *Proceedings of the Highway Research Board* (Part 1, 1934), indicated that cracks in a plain concrete base without joints average about 60 ft apart in a period of two years and that these cracks are reproduced in the asphalt wearing course.

Their experiments with a plain concrete base with 1/2-in. expansion joints 30 ft apart produced cracks where designed. The objection to this type of construction was slowness of installation, development of double cracks in the asphalt surface caused by the cover plates over the joints, and lack of load transfer across straight joints. A third section having a plain 6-in. concrete base with dummy joints 1 1/2 in. deep, spaced from 12 to 21 ft apart, produced cracks in the asphalt surface over dummy joints at intervals of 45 ft or more. Concrete base containing wire mesh 2 1/2 in. below the surface and lapped 4 in. across the dummy joints (which were spaced at intervals of 24 ft) was broken at longer intervals, the maximum being 160 ft. The fourth type of base, reinforced with a continuous wire mesh which held the base intact in long sections, exhibited no particular uniformity in spacing or alignment of cracks. These results seem to be in accordance with experience in the Cleveland area, where observation of base failures led that city to specify that contraction cracks in the concrete base for asphaltic pavements be placed at 70-ft intervals.

Considerable experimental work has been done to produce stable pavements with mixtures of asphalt and mineral matter, and this research has led to asphaltic mixtures which are more durable as well as more compressible. Pavements designed with a consideration for compressibility and stability will be dense, will have a minimum distortion in hot weather, and will be weather-resistant. In some cases stability may be increased by the use of soft rock; however, hard tough rock is to be preferred as it offers greater resistance to the abrasive action of traffic. When aggregate breaks into smaller particles it requires more bituminous cement to bind the additional surfaces together, and since this binder is lacking, the pavement will ravel and pit under traffic, and moisture settling in the pit holes will start its destructive action. The stability, or wearing qualities, of the asphaltic mixture is not critically affected by the hardness of the fine aggregate, although two sands having the same size gradation may affect the compressibility of the mixture differently owing to a phenomenon

termed "surface texture," which is not measurable by any of our present tests.

A fine mineral filler is used in the asphaltic mixture to reduce the voids and increase the workability and stability of the mixture. Limestone dust has been used most extensively for this purpose, although dust of silica, slate, and shale, as well as diatomaceous earth, portland cement, and hydrated lime have also been used successfully. Within the limits of workability and compressibility of the mixture, the filler producing the lowest percentage of voids, other things being equal, will be the most economical with respect to the asphalt required.



Filler Extruding from Brick Pavement on Dead-End Street

Taking Away the Seal Results in Complete Disintegration

EXAMPLES OF TOO MUCH AND TOO LITTLE ASPHALT FILLER IN BRICK PAVEMENTS

COMPRESSIBILITY OF MIXTURES IMPORTANT

To have satisfactory weathering and wearing properties, the resulting mixture should be one which can be compressed to within 95 per cent of its theoretical maximum density upon being subjected to a pressure of 5,000 lb per sq in., either by rolling with a 10- or 12-ton roller, or by other means. The compressibility of the mix is one of its most important properties because it affects the resistance of the pavement to moisture-cracking, raveling, and surface stability. Sheet asphalt pavements will have a maximum compressibility when approximately 12 per cent of filler is used; however, the compressibility should be determined experimentally in each case.

The proportion of bituminous material should be sufficient to fill the voids. Less than this reduces compressibility, while more represents quantities greater than those ordinarily used in practice. The function of bituminous cement is to bind the individual particles together to an extent that the inherent stability is sufficient to prevent displacement under traffic and to prevent moisture from penetrating the pavement. The bituminous pavement should be regarded as a plastic mixture, and sufficient bituminous material should be used to retain such plasticity even though smaller amounts might be used for either compressibility or stability.

Cracking of the surface is often attributable to lack of traffic. Streets in undeveloped subdivisions having little or no traffic are usually cracked, while similar pavements on well-traveled streets stand up for years. Some believe that traffic kneads the cracks together and others that oil dripping from cars facilitates the kneading action. The tension produced by contraction may be relieved by traffic or by supplying sufficient asphalt in the surface to give elasticity to the pavement.

Scaling of asphalt surfaces occurs most frequently with coarse mixtures lacking in bitumen. It usually takes place when streets are wet by runoff water from adjacent territory.

The denser sheet-asphalt type of pavement usually applied to city streets may be varied by selecting the asphalt with attention to its softening point, ductility, and penetration. The specifications for this type of pavement must be carefully considered as the surface will usually crack at irregular intervals owing either to contraction or to brittleness at low temperatures. There has been a tendency in some locations to specify a low penetration for these mixes when subjected to heavy traffic, without regard to the temperature range of the base upon which it is being placed. For example, a road on a good foundation which is subjected to heavy traffic will stand up best using the low-ductility stiff asphalt mixtures; but this same pavement, if continued as the surface for a bridge in a cold climate, will undoubtedly crack at frequent intervals owing to its brittleness at low temperatures. Cracks in a pavement should be filled as soon as they are noticed, in order to protect the pavement and prolong its useful life.

COLD WEATHER TESTS

It has been the observation of those dealing with asphaltic pavements that low temperatures play an important part in the breaking up or cracking of the pavement. At extremely low temperatures the pavement no longer acts as a plastic mass but becomes a brittle solid obeying laws of stress and strain like concrete and other solid materials. The work of L. F. Rader, Assoc. M. Am. Soc. C.E., in his study of "The Physical Properties of Asphaltic Mixtures at Low Temperatures," is undoubtedly the initiation of a new type of investigation. Professor Rader made tests to determine the flexural strength and modulus of elasticity of small asphalt beams at temperatures as low as -70 F. Among the conclussion presented in his article, "Investigations of the Physical Properties of Asphaltic Mixtures at Low Temperatures" (*Proceedings of the American Society for Testing Materials*, 1935), the following may be mentioned:

"1. Sheet-asphalt mixtures chilled to low temperatures are brittle materials having definite load-deflection curves. The mixtures tend to become stiffer and more brittle with decrease in temperature.

"2. Compaction of sheet-asphalt paving mixture is important to develop tensile strength at low temperatures.

"3. Asphalt cement in sheet-asphalt mixtures in amount required to fill approximately the voids in the mineral aggregate is desirable in order to decrease stiffness and develop tensile strength and toughness at low temperatures.

"4. The mixtures composed of steam-reduced Mexican and Mid-Continent asphalts and oxidized Mid-Continent and Colombian asphalts of about the same normal penetration showed no great differences in stability, modulus of elasticity, and modulus of rupture, but these oxidized asphalts showed higher toughness values.

"Based on the results of tests illustrating the various characteristics of sheet asphalt mixtures, . . . the following indications have been developed:

"1. Asphalts of high susceptibility to temperature change, as illustrated by cracking oil asphalt, produce mixtures which are least resistant to cracking at low temperatures, as indicated by their high modulus of elasticity, low modulus of rupture, and low toughness.

"2. For the usual paving grades of asphalt, source and method of refining as covered by this investigation would appear to have little relation to resistance to cracking of sheet-asphalt paving mixtures except that the oxidized asphalts in general develop somewhat higher toughness, which should be advantageous from the standpoint of resistance to impact failure.

"3. Other factors being equal, it would appear that those mixtures containing the highest penetration asphalt and the highest percentage of asphalt consistent with necessary stability should prove most resistant to cracking at low temperatures."

It has been the observation of the author that cracks due to temperature are apt to occur in the spring of the year when the temperature range is from 25 to 40 F. Contraction caused by reduction in temperature produces a tensile stress in the asphaltic mixture which may be calculated by the expression

$$S = ctE$$

where S = tensile stress in pounds per square inch
c = thermal coefficient of expansion per degree Fahrenheit
t = total temperature change in degrees Fahrenheit
E = modulus of elasticity in pounds per square inch

Tensile stress is developed if the ends and edges of the pavement are restrained. Cracking will result if the contraction resulting from a change in temperature produces stresses in excess of the tensile strength of the pavement. In Fig. 1 (*a*) is shown the correlation of the modulus of elasticity with temperature, and in Fig. 1 (*b*) the modulus of rupture with temperature.

The coefficient of expansion of asphalt pavements is reported by the late Clifford Richardson (*The Modern Asphalt Pavement*) as 0.000014 and 0.000028. If it is assumed that the asphaltic mixture changes from a plastic mass to a solid at 40 F, stress will result if the solid is cooled below this temperature. Cracking will occur where the theoretical temperature stresses plotted in Fig. 1 (*b*), exceed the modulus of rupture, or at 36 to 38 F.

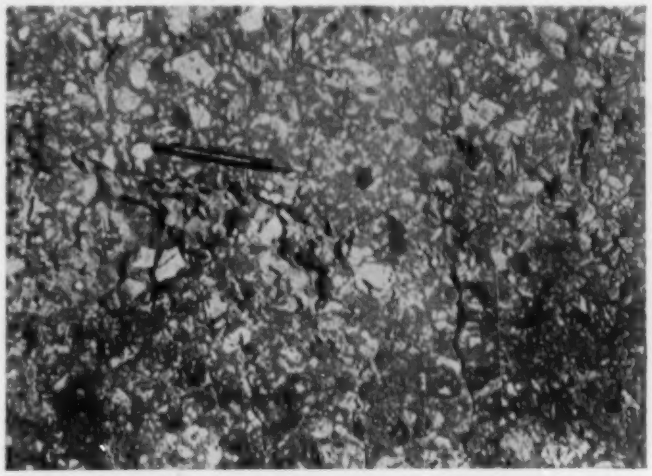
This analysis is approximate at best, but it illustrates that an asphalt pavement if restrained should fail by contraction resulting from temperature changes at a temperature slightly below that at which the mixture may be regarded as a solid. Further investigations of the flexural strength of pavements which have been in service for many years would aid in the design of future pavements, and it is hoped that such investigations will be carried out.

ASPHALTIC BRICK FILLERS

Probably one of the best means of studying the weathering of asphalt is in brick roads using an asphaltic filler. The modern brick road has the surplus filler removed from the surface, leaving a non-skid pavement in contrast to the slippery one resulting from the old practice of allowing the filler to extrude from the cracks and remain on the pavement. The present method of removing the surplus bitumen takes away the seal which formerly prevented entrance of water into the joints.

The result is that in a surprisingly short time the bond between the filler and the brick is broken down and oxidation of the bitumen takes place, with water leaching away the filler. The city of Cleveland is testing experimental stretches of filler consisting of a mastic mixture of asphalt, maltha, and fine sand. This is placed by the "squeegee" method, allowing the filler to cover the bricks with a thin layer presenting a non-skid surface. Cleveland is also experimenting with a similar filler using powdered asphalt.

The native bitumens contain a group of hydrocarbons known as malthas, which are viscous liquid bitumens. Richardson states that "they are only rarely of a suitable character for use as a flux, owing to the fact that on heating they are rapidly converted into a harder mate-



Raveling Offers Opportunity for Disintegration

rial by the loss of volatile hydrocarbons and condensation of the molecule."

As a contrast to Mr. Richardson, J. W. Fraser, of Cleveland, Ohio, has been experimenting with malthas as found in Kentucky rock asphalt and Ohio bituminous dolomite, which he finds to be weather-resistant when mixed with blown asphalt. Mr. Fraser contends that the malthas contained in the dolomite add a group of hydrocarbons to the blown asphalt which makes the resultant mixture approach the native asphalt in physical and chemical properties. Cleveland has used maltha mixtures on some resurfacing over old brick roads, which are standing up very well under heavy traffic.

The selection of the type of pavement for the particular purpose the road is to serve is an important element in the weathering qualities of the surface. Economic considerations as well as engineering design must be carefully weighed in the selection of the type of pavement to be used in a particular location. Maintenance is an important factor in the selection of an economical design. Pavements should be designed for modern traffic, and while the automotive industry provides rapid acceleration of the motor vehicles, the paving designers of today must provide for rapid deceleration when laying pavements. This leads to the adoption, for the sake of safety, of non-skid or "sandpaper-finish" pavements. These are apt to be of open-type construction, in which the pavement surface is left in a rather rough state (and in the case of asphaltic concrete the coarse aggregate exposed on the surface). This type of pavement, while assuring the utmost in safety, is at the same time an invitation to weathering. Coarse aggregate exposed on the surface will be subjected to cycles of freezing and thawing, and heat and cold until the weaker particles finally disintegrate. Places for moisture to settle in are left by the spalling out of the aggregate. The cycle of sunlight, heat, oxidation, and carbonization takes place; the color of the surface changes; and in time the asphaltic binder becomes dead and is leached away as disintegration of the road progresses. Careful maintenance is the only means of retarding this action. These non-skid surfaces can be maintained with an application of cut-back asphalt followed by stone or slag chips rolled into the surface. The saving of the road, to say nothing of the saving of human lives, justifies this expenditure.

Traffic Volumes and Highway Costs

The Relation Between Traffic, Street Capacities, and Expenditures for Highway Improvements

WITH the rapid increase of automobile traffic witnessed in recent years, many new problems have been created, both in urban and rural districts. Problems of traffic volume in cities were discussed directly in two addresses delivered at the Society's Pittsburgh Meeting on Thursday morning, October 15, 1936, while volume and cost of automobile operation outside commercial districts form the underlying basis for a paper, presented Thursday afternoon, on the economic justification of expenditures to improve highway alignment, grade, and width. Both sessions were arranged by the City Planning Division and the Pittsburgh Section. Because of the possibility that these papers may be treated more fully in Society publications at a later date, brief summaries of them only are presented here.

A careful analysis of the several causes for the failure of congested city streets to handle the traffic volume of which they are capable is made in Mr. McIntyre's paper. Various remedies for this situation are discussed by Mr. McNeil, including devices for reducing delays arising between direct and cross traffic at intersections; between free-moving, parking, and stationary vehicles; between vehicles moving in the same direction; and between those moving in opposite directions. Mr. Schmidt presents methods for determining the characteristics of a proposed highway, based on the least estimated annual expenditures for fixed charges, automobile-operation costs, depreciation, and maintenance.

Factors Limiting Traffic Capacities of Streets

SEVERAL CAUSES of the failure of the congested city streets to handle the volume of traffic of which they are capable were carefully analyzed by Lewis W. McIntyre, M. Am. Soc. C.E., consulting engineer, and member of the Pittsburgh Planning Commission. Mr. McIntyre's paper, which was based on actual studies made in Pittsburgh under direction of the Bureau of Traffic Planning, lists four causes of loss in traffic capacity.

These four types consist of cross interference, caused by the entrance of vehicles and pedestrians from other streets; marginal interference, arising from the presence of parked cars and other objects on lanes next to the curb; internal interference, caused largely by drivers who weave from lane to lane; and medial or center-line interference, a result of conflicts caused by cars moving in opposite directions along the center-line of a street. The maximum capacity of a single lane of traffic in congested districts is 2,000 to 2,500 passenger cars per hour, moving at speeds of from 11 to 15 miles per hour. Actual traffic in downtown Pittsburgh, due to interference, is 132 to 754 cars per hour per lane.

Interference by cross traffic is the most obvious cause of loss of traffic capacity. Although separation of grades is the only way to eliminate such interference, the proper timing of signals will reduce it materially. Construction of additional distributing streets may be necessary in some cases. Cross-traffic interference, in addition to its direct effect in occupying intersections, is also the source of the delay caused by the stopping of vehicles, which reduces lane capacity from 30 to 50 per cent. Another form of cross interference is caused by pedestrians walking against red traffic lights. Tests in Pittsburgh showed that up to 56 per cent of pedestrians fail to stop at red lights, but as yet no effort has been made to reduce this "jay walking," except through education.

Turning delay is still another important form of cross-traffic interference. One passenger automobile, turning left from the center lane of a two-way, six-lane street, will delay traffic behind it by an amount of time equal to that required for four such vehicles to go straight through. A street-car train, in making such a turn, may take the time of 21 passenger cars to move through a lane in the opposite direction. It should be remembered, however, that from an economic angle, one street car train of the kind referred to can carry two or more times as many passengers as all the 21 automobiles combined. In making turn-elimination studies, two alternate routes must be provided for each turn eliminated, in case the motorist misses the first one.

Marginal interference, the second type listed, is caused by vehicles entering and leaving garages, and parking or parked along the curb, and by the natural slowing down of cars moving in lanes adjacent to the parking lane. The average stopping time of all vehicles in downtown Pittsburgh is 21 1/2 minutes. Of the cars that stop, 48 per cent are loading or unloading, and stay an average of 8 1/2 minutes; those parked while occupants are shopping represent 24 per cent, and require an average of 24 1/2 minutes; while the cars of persons who are working or engaged in recreation total 28 per cent, and remain for an average period of 37 minutes. Enforcement of "no parking" ordinances and of suitable property-use regulations would help to reduce marginal interference.

Internal interference is caused by the weaving of drivers from one lane to another, conflicts arising between cars in adjacent lanes, the provision of lanes of inadequate width, and similar difficulties. Rough pavements and steep grades are also contributing causes, although grades of less than 5 per cent have little effect. Poor street illumination also has an adverse effect on traffic capacity. Weaving causes a 40 per cent reduction in speed in the lane from which the weaving starts, and a 30 per cent reduction in speed in the lane which it enters, and each weaving vehicle displaces from one to six vehicles moving straight through.

Taxicabs are also a leading cause of internal interference, particularly if they are permitted to cruise in search of passengers. In one block in downtown Pittsburgh taxicabs made up 25.8 per cent of the total traffic. Out of a total of about 4,600 cabs counted in this study, 76.7 per cent were empty. Trucks and street cars are important factors in reducing street capacities on account of their slow speeds. Where possible, trucks should be confined to streets not congested with passenger cars, and those which follow fixed routes every day should be routed over secondary thoroughfares. The use of high-speed street cars, together with carefully timed signal lights, will help to reduce delays from this source.

Loading zones permitting the by-passing of motor traffic are of further help.

There is another type of traffic which reduces lane capacity in most congested districts. This is through traffic. In downtown Pittsburgh 49.7 per cent of the vehicles that enter the triangle leave through another throat within 20 minutes. This means that about half of the traffic that is congesting city streets does not bring any business to the district. If proper by-pass routes were available, this space could be used by cars bringing business to the city.

Our present habits of street construction and use, said Mr. McIntyre finally, are seriously reducing street capacity. City planners would do well to recognize the many means of increasing street capacity which can be put into practice at moderate expense.

Increasing the Traffic Capacities of Streets

CONGESTION IN THE streets of American cities, caused by the rapid increase in automobile traffic, has reached a point where business is suffering, according to Donald M. McNeil, Jun. Am. Soc. C.E., acting traffic engineer of Pittsburgh. Average speed of vehicles in the main business section of Pittsburgh has been so reduced that the time required to leave the section as compared with that required if there were no delays is five times greater for automobiles and three times greater for street cars. The cost of delays during the peak hours of one day may be estimated conservatively at $100,000, neglecting the cost of the accompanying accidents. Many of the delays now causing congestion can be eliminated, however, and the capacity of the street system increased. The various delays may be classified as due to cross, marginal, internal, and medial interferences, respectively.

The remedy for delays caused by cross interference lies in eliminating, reducing, or so regulating cross traffic that it will not arrive at the point of prospective conflict at the same time as the traffic on the highway under consideration. Where vehicles are concerned, this may be accomplished by providing grade-separation intersections or elevated roadways, by a progressive coordinated signal system or its equivalent, by eliminating turns, by requiring left turns to be made in a U-movement (if sufficient street widths are available), by providing a far-side right-turn circle roadway to replace the left-turn movement, by providing a circular roadway, and by channelizing wide uneven intersections. In the case of pedestrians, cross interference may be eliminated by rigid enforcement of pedestrian regulations (prohibiting crossing against a red light and "jay walking"), by providing a pedestrian interval during which no vehicles may move and all pedestrian movements must take place, by connecting the basements of large buildings by pedestrian tunnels (a partial remedy), and by construction of pedestrian underpass tunnels.

Marginal interference is caused by street and off-street parking and by the loading and unloading of vehicles. It cannot in the nature of things be eliminated entirely, but may be reduced in a variety of ways, as by restricting all stopping of vehicles for loading and unloading during rush hours, and by prohibiting parking. Delays may also be reduced by requiring that entrances to parking lots and garages shall open upon streets having the least congestion and preferably upon streets which are not main traffic arteries.

Internal interference is that type which takes place between traffic units moving in the same direction in the same traffic area. It is caused in general by differences in speeds of the various vehicles, by the tendency of certain vehicles to foul adjacent lanes, and by any physical conditions of the roadway which may tend to reduce the speed of vehicles. Insufficient width of traffic lanes is a common cause. Nine-foot or (preferably) ten-foot lanes should be provided. Curb radii of 6 to 10 ft, as used in the past, restrict the speed of turning, and radii of 20 to 35 ft are needed today. Adequate street lighting will permit drivers to proceed safely at a higher rate of speed, as well as reduce accidents.

STREET-CAR LOADING PLATFORMS REDUCE TRAFFIC DELAYS
Note That Two Lanes Are Open Between the Car and the Curb

Weaving of vehicles from one lane to another causes internal interference, but is essential in many cases to provide flexibility, as at traffic circles, for example. Delays due to unnecessary weaving may be eliminated by channelizing the roadway. The use of large trucks causes internal interference on account of the slow speeds at which they usually travel. Provision of off-street loading facilities and restriction of parking in alleys or secondary streets to commercial vehicles only will reduce delays due to stopping of traffic by trucks.

The operation of taxicabs in congested areas creates still another form of internal interference, particularly during rush hours. Taxicabs, if vacant, travel at slow rates of speed. Delays from this source may be remedied by requiring taxicab companies to provide adequate off-street facilities and by rigidly enforcing ordinances prohibiting cruising and slow driving. Cruising passenger cars create similar delays, which may sometimes be eliminated by prohibiting parking or by restricting turns. Probably the most serious type of interference is due to the loading and unloading of street cars and busses. Coordination of traffic signals so that such vehicles will arrive at their stops on a red signal is a practical remedy. Another and very effective one in the case of street cars is provision of loading platforms. The use of one-way streets is another well-known device, but care should be exercised to avoid unnecessary traveling and turning.

Medial interference is that which occurs between vehicles moving in opposite directions at or near the center of a street, and may be due to insufficient width of traffic lanes or to the action of vehicles in swinging out on the wrong side of the road to pass others going in the same direction. Center-strip islands will eliminate medial interference, but unfortunately their construction is generally impracticable in congested districts.

In closing, Mr. McNeil mentioned some general remedies for traffic delays, including staggering business

hours; staggering industrial and food deliveries; analyzing and surveying existing mass transportation systems, to offset the use of private automobiles and substitute common carriers scientifically routed; providing by-passes for through traffic; and enforcing parking restrictions. Although traffic and city planning engineers are responsible for the solution of such problems, they would do well to seek the support of citizens for their recommendations.

Effects of Alignment, Grade, and Width on Costs of Major Highways

WHILE IT IS impossible to present general formulas for the effects of alignment, grade, and width on the direct and indirect costs of major highways, according to Edward L. Schmidt, former chief engineer of the Allegheny County Planning Department, Pittsburgh, Pa., methods in use in that department have nevertheless proved valuable in studying the economics of expenditures for major highways.

In the old days the best route for a highway was deemed to be that upon which the improvement could be constructed with the least direct outlay. But with the development of the automobile has come the realization that operating costs should be considered. Today the best route is one which will connect the terminal points by the shortest possible travel consistent with reasonable convenience, safety, and economy.

Costs involved in highway construction may be classified as direct and indirect. Direct costs, which represent expenditures for physical construction, consist of the costs of right of way and damages, construction, overhead, and depreciation and maintenance. The principal indirect costs are automobile-operation and automobile-accident costs. On this basis, the best route for a proposed highway may be redefined as that which requires the least annual expenditures for fixed charges, automobile-operation costs, depreciation, and maintenance. The starting point in highway problems is therefore traffic. This varies with the type of community.

In commercial districts the ideal would be attained if no major thoroughfares existed. Where by-passes are impracticable, through traffic should be routed through streets wide enough to provide not less than four lanes for moving traffic, as well as adequate parking spaces. Since automobile velocities average only about 15 miles per hour, the use of short-radius curves and curved alignment is not serious here. On the other hand, maximum grades should not exceed 4 per cent.

Outside commercial districts, traffic characteristics vary widely, and the desirable amounts of curvature, gradient, and width of roadway depend upon the volume and speed of such traffic and the general topography. The theoretical maximum capacity of a single roadway lane is 2,000 cars per hour at 20 miles per hour. Practically, however, the "working" traffic capacity is reached when any further increase in traffic volume results in a marked decrease in traffic speed. Experience in Allegheny County indicates that the working capacity of a two-lane roadway approximates 600 vehicles per hour, and that whenever the average daily density exceeds this figure for three or more hours per day, widening should be considered. If widening is thus found necessary, four lanes are safer than three, and will carry up to 50,000 vehicles per day without appreciable congestion. If more than four traffic lanes are required, it is generally better to construct an additional thoroughfare. With four or more traffic lanes, divided roadways are safer. The center strip between divided roadways should, where practicable, be not less than 40 ft.

Except as it affects distances, curvature does not appreciably influence automobile-operation costs, provided proper radii and length, superelevation, sight distances, and roadway widening are used. Desirable minimum standards are: For sight distance, 800 ft; for horizontal curvature, a 1,000-ft radius; for vertical curvature, a sight distance of 500 ft. In Allegheny County all curves on two-lane roadways which exceed one degree of curvature are superelevated at the rate of 1/8 in. per ft of width per deg of curvature, approximately, with a maximum of 1 in. per ft. Grades are kept as low as practicable and never exceed 8 per cent.


SOUTH PORTAL OF THE LIBERTY TUNNELS
Connecting Downtown Pittsburgh with the South Hills District

Of all the direct costs of highway improvement, those of rights of way and damages are the most variable. In Allegheny County, outside commercial and dense residential areas, a 60-ft right of way costs about $25,000 per mile, and a 100-ft right of way, $40,000 per mile, on an average. Construction costs run about $75,000 per mile for two-lane roads and $140,000 for four-lane roads. Costs of overhead average about 15 per cent of the total estimated costs of right of way and construction, and costs of maintenance about $1,000 per mile for two-lane roads and $1,200 per mile for four-lane roads.

To evaluate the benefits to traffic which accrue by the reduction of travel distances and traffic delays, an estimate of automobile-operation costs is necessary. Results of traffic surveys in Allegheny County indicate that the average costs of automobile operation per mile, on a basis of 12,000 car-miles annually, are 6.56 cents for passenger cars used for pleasure, 11.56 cents for passenger cars used for business, and 23.33 cents for trucks. Savings due to reductions in distance are computed at 5 cents per vehicle mile, or 1 cent per 1,000 ft. Savings by reduction of delays are conservatively estimated at 1.25 cents per vehicle minute. A good average value for savings by reduction of accident hazard is about 1 cent per vehicle mile.

Applying the unit values thus derived, modified as required to meet special conditions, the Allegheny County Planning Commission has investigated the economic justification for all projected improvements of major highways, with gratifying results. As an example of these results, Mr. Schmidt quotes the Liberty Tunnels, connecting downtown Pittsburgh with the South Hills residential district. The construction of these $5,000,000 tubes has resulted in a daily saving of both time and distance to some 25,000 cars. This is equivalent to more than 9,000,000 vehicles per year. Allowing only 10 cents per vehicle, the annual saving to traffic is $900,000. Capitalizing this at 6 per cent, the worth of this saving is $15,000,000.

Recent Eastern Floods and the National Aspects of Flood Control

AGAINST the devastating eastern floods of 1936 there must be charged, at a very conservative estimate, at least $300,000,000 of direct damages. To this sum must be added the indefinite but tremendous economic loss to the entire country that resulted from the tying up of transportation and utilities and the consequent disruption of markets. And finally there must be debited an item that cannot adequately be evaluated in dollars—the loss of many lives.

The single item on the credit side of the ledger perhaps cannot balance this account, but it is at least an appreciable offset; the floods of 1936 served to crystallize public opinion, establish a comprehensive federal policy in regard to flood control, and stimulate a definite program that will go far toward making future floods less frequent and less devastating. The Flood Control Act of 1936 recognizes that floods are a menace to national welfare, and provides for federal participation in flood control projects not only where the dollars-and-cents benefits exceed the estimated costs, but where life and social security are otherwise adversely affected.

At the Pittsburgh Meeting of the Society, on October 13 and 14, 1936, two general sessions and two technical sessions under the auspices of the Waterways Division were given over to a consideration of flood control problems. The present symposium comprises digests of the eight papers read at these sessions. Because these papers are now scheduled to appear in much more complete form in the March 1937 issue of "Proceedings," brief summaries only are presented here. The opening papers stressed the legal arguments for federal responsibility in flood protection, the problems in developing a national policy, and the economic aspects of flood control projects. Against this background, succeeding speakers described in detail the causes and results of recent floods in New England, New York, and the upper Ohio basin. Next, ways of improving the flood-forecasting service of the Weather Bureau were pointed out. The symposium concluded with an explanation of the Flood Control Act of 1936 and a description of the specific projects proposed for protection of areas in the Ohio River basin.

Federal Responsibility for Flood Control

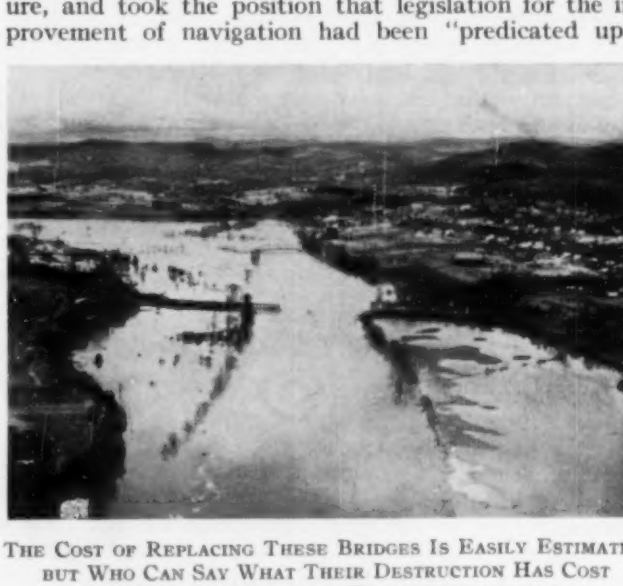
In opening the symposium on flood control, U. S. Senator James J. Davis stressed the importance of federal participation in any comprehensive flood-control program. As a specific example, he pointed out that plans for the protection of Pittsburgh have not been put into effect largely because they require inter-state action, and it is not possible for Pennsylvania to carry out the project in its entirety without assuming more responsibility than it rightly should. National control and action are necessary.

The conception of flood control as a problem of major national importance, deserving consideration in its own name and on its own merits, has been developing gradually over a long period. Although the Swamp and Overflowed Land Acts of 1849 and 1850 cannot be considered strictly as flood control legislation, they do represent the actual beginning of federal aid for flood control. The Ellet report in 1852 concluded that control of floods on the Mississippi was the nation's duty and that it was a question that "must be decided by the justice and humanity of the nation."

In 1878 the Rivers and Harbors Bill provided $1,000,000 for aiding navigation on the Mississippi. This money was spent under the supervision of the Army Engineers, who favored levees; thus the Army Engineers came to support those who wanted levees to control floods. The combining of the groups desiring flood control and the groups interested in navigation was again plainly evidenced in the debate on the bill creating the Mississippi River Commission in 1879; this bill put the United States definitely into flood control work, and probably stands as the most important piece of flood control legislation in our history.

A strong argument for federal participation in flood control is that the United States owns the rivers and has paramount jurisdiction over them. The conclusion follows that the United States should not permit this property to damage the citizens of any section. Added reasons for federal responsibility are the important considerations of interstate commerce—including the postal service—public health, and national defense.

Several strong points for the constitutionality of flood control by the federal government have been advanced, but the one that has furnished the bulwark for most of the arguments along that line has been based on the jurisdiction of the federal government over interstate commerce. However, in 1917 proponents of flood control sought to establish the right to control the Mississippi under the commerce clause on a wider basis than that of merely improving navigation. They frankly stated that it was a flood control measure, and took the position that legislation for the improvement of navigation had been "predicated upon



The Cost of Replacing These Bridges Is Easily Estimated, but Who Can Say What Their Destruction Has Cost the Nation in Delayed Transportation and Disruption of Markets?

the power of Congress to regulate commerce," for the word "navigation" did not appear in the Constitution, but had been written in as a part of the interpretation of the commerce clause. They turned their attention to statements of legal authorities and to court decisions, apparently with satisfactory results.

The general-welfare clause has naturally furnished a strong point for those who sought to establish the constitutionality of flood control measures. To many the government has as much right to make land suitable for habitation by protecting it against floods as it did to give away the public domain. Congress has been liberal in voting money to relieve flood victims, and it has been urged with apparent logic that appropriations for protection mean as much for the general welfare as appropriations for relief, and that they are therefore just as constitutional.

It has been suggested that the cost of control should be borne by the various states in proportion to their responsibility for the floods, but the difficulty of apportioning costs on such a basis appears insurmountable. The problem is complex when only the natural causes of floods are taken into account, and it becomes more so when the effects of existing protection and drainage works are considered. The way out of such a difficulty would seem to be provided by federal control.

But a satisfactory public policy can never be developed under present conditions. When it is realized that the federal government, the states, levee boards, cities, counties, railways, and individuals have been building levees, and that ten agencies in the Departments of War, Interior, Commerce, and Agriculture, to say nothing of PWA and WPA, have had separate authority in the development and control of streams, it appears rather remarkable that the work already completed has been performed as well as it has been.

Federal control has been delayed because of the large sums involved, because of sectionalism, disagreement on methods, and questions of constitutionality. But none of these arguments has weighed as mightily as the general inertia of the public in forcing the issue. Organized representation has not been sufficiently persistent. The engineering profession deserves to be recognized for the support it has given to the program of federal flood control. Engineers have appeared times without number as witnesses before congressional committees. No other group of financially disinterested persons has more generally urged complete control of the floods of the Mississippi and its tributaries.

It appears that the people of the United States have now finally realized that floods will continue to increase in importance. Floods have not become more frequent but they have become more dangerous. This is now a national problem and must be considered fully as a federal responsibility.

Problems in Developing a National Flood Protection Policy

DEVELOPMENT OF A national flood-protection policy should not be separated from that of a national policy governing water resources in general, said Abel Wolman, M. Am. Soc. C.E., chairman of the Water Resources Committee of the National Resources Committee. The elements of such a policy run the gamut of engineering, finance, and administration, and are bound up with the problem of public prejudice and pressure, but engineering thought is the key to their ultimate determination.

Detailed and carefully prepared programs for flood control are lacking in many areas. Hydrological data are incomplete, and must be amplified and kept up to date to provide a sound basis for any flood control program. What part detention reservoirs, channel improvements, forestation, soil conservation, and so-

THE TYGART RIVER RESERVOIR DAM AT GRAFTON, W.VA., ON NOVEMBER 6, 1936

This Project, Under Construction by the Corps of Engineers, Will Help to Reduce the Flood Menace at Pittsburgh

called "upstream engineering" should play in a general water-resources program still remains to be demonstrated conclusively. Detailed field and office analysis alone can disclose the relative merits of the various devices and procedures. Engineering guidance for public opinion is more necessary today than at any time in the past.

Most people assume that the economic justification for flood protection is simple to evaluate. It is surprising, however, to find how little information is available, not only on specific flood damage, but on the general, special, and intangible benefits that might arise from a given flood-protection project. Various procedures have been used in making such evaluations, but the details are rarely so presented as to make the evaluation readily subject to check. Since assessment of local benefit—which is presumably the basis of local participation—is still in such a nebulous state, the difficulty of adhering to what appears to be a sound policy is apparent.

The question of how much central responsibility for flood protection the federal government should assume is more difficult to answer when viewed in the light of specific undertakings than when stated as a general principle. One reason is that the mere definition of "federal interest" is continually undergoing adjustment. In such a complicated problem, slow motion would seem to be a sound principle of action. Heroic changes in procedures of federal-local responsibility should be approached with caution.

The Flood Control Act of 1936 illustrates that a simple formula for local participation may produce many inequities. A logical substitute for the "formula" type of legislation lies in a flexible administrative control. A trial-and-error technique is a prerequisite to ultimate solution.

If future water development is to be guided by a comprehensive study of possible multiple uses, other problems are introduced. Decisions must be made from time to time as to what governmental or private agency shall be permitted to undertake the construction of vast water-resources programs. In the development of

principles and policies, much more than engineering information and conclusions is involved. A kind of statesmanship and creative thinking, not yet fully developed, is needed, which will balance local and national needs and costs against assessment of benefits. A new sense of social responsibility on the part of local areas is also required.

The operations of the Miami Conservancy District, the Muskingum group, the TVA, and the Corps of Engineers on the Mississippi flood control work, are all indicative of a distinct although unconscious, desire to direct public action into logical engineering, financial, and administrative channels. Their varied experiences disclose a gradual evolution toward an emphasis on multiple uses of streams, on drainage-basin concepts, and on federal-local participation.

To the approaches just noted, the Water Resources Committee has added several undertakings that are further examples of multiple-use studies of streams, and of cooperative endeavor. The investigation of the Red River of the North resulted in a report proposing an adequately developed water plan on a long-time basis; it is perhaps the first comprehensive program of its kind carefully developed in this country with three state groups participating and with competent engineering control and direction. The findings of this report are now being put into effect by local groups, and where money is being spent by federal agencies, it is spent in accordance with the plan. This development illustrates that it is feasible, with a certain amount of central direction and stimulation, to interest individual states in the preparation of a joint comprehensive program of action.

Among other similar studies now under way may be mentioned the investigation of the Rio Grande River, which involves the cooperation of various federal agencies and three state bodies; and the Kansas River flood studies, which illustrate the merit of joint review by the Corps of Engineers and the local flood-control committee and its engineer advisers.

Most members of the Society are familiar with the national drainage basin study that the Water Resources Committee now has under way. Its purpose is to indicate the outstanding water problems in the various drainage areas of the country, to fit them tentatively into integrated patterns of water development and control, and to present, where existing data make it possible, specific construction and investigation projects as elements of an integrated plan. The results of these studies should as time goes on disclose certain principles of action and should supply the basis for an ultimate national policy, flexible in character, logical in administration, and as free from prejudice and greed as possible.

The Economic Aspects of Flood Control

Until recently, flood control projects have been evaluated on a rather strict basis of dollars and cents, said Nathan B. Jacobs, M. Am. Soc. C.E., consulting engineer, Morris Knowles, Inc. Average annual damages direct and indirect, have been evaluated, and the proposed project has been considered sound only if the total annual charges are less than those damages.

Now, however, a more humanitarian concept is recognized by law. The Flood Control Act of 1936 provides that the federal government may participate in flood control "if the lives and social security of people are . . . adversely affected." The construction of flood control projects on a purely monetary economic basis is a thing of the past.

Where the lives of human beings are endangered, protective works should be constructed. It is too much to expect that people shall move from the path of danger. Human nature will not change, and it seems to be the spirit of some to reside in danger zones. Further, the returning to homes—or the location of former homes—after a disaster may not be so much a matter of choice as of compulsion. Many industries must be located near rivers, and many workers must live in homes nearby for reasons of convenience and economy.

The most economical method of flood control for any given area can only be ascertained after a comprehensive study. A comparison of the initial cost of construction of various schemes is necessary. It is also essential that those who must pay for the work have full knowledge of the cost and the benefits. The fact that floods cannot be prevented should be stressed by the promoters and designers of projects.

In regard to retention reservoirs, there are two schools of thought. One holds that the reservoirs should be for flood control only, and should function automatically. The other advocates multi-purpose basins. The basis for choice should be the degree of protection desired. Multi-service reservoirs may not provide maximum protection from floods; on the other hand, automatically controlled retention basins may hamper the conservation of water for other uses.

Who should pay for flood control? Those who live in the flood path do not consider the cost to be a local problem; those outside the path often object strenuously to bearing a part of the burden. Flood disasters, however, have far-reaching effects, and indirectly the entire nation suffers. After a flood, the territory surrounding the inundated area generally suffers a slowing up of business activity and a depreciation in property values. Losses occur outside the flooded zone through the disruption of utility services; the commodity market is disturbed; the federal government itself suffers losses, especially where navigation is affected.

During the Spring Flood of 1936, Water Reached the Second Floors of These Homes at Sharpsburg, Pa.

The distribution of cost of a flood control project among the beneficiaries is difficult. It cannot be determined by any given formula; each case is a law unto itself. However, as nearly as may be, all interest—private parties, the city, the community, the state, and the nation—should pay their share in accordance with

the benefits received. If navigation is benefited by the regulation, the federal government should pay an additional share. Water power interests should also contribute to the cost of any project that improves flow conditions. The main object of a flood control project should be flood control, but if other interests can be benefited, the system should be designed with that end in view.

Recent examples of cost distribution may be of interest. The Pymatuning Reservoir in Pennsylvania was built entirely by funds appropriated by that state, except for certain land and flowage rights in Ohio, acquired by interested parties and donated to avoid legal difficulties. In the case of the Sacandaga Reservoir in New York, 95 per cent of the cost was assessed directly against water power properties. The cost of the Miami Conservancy District system in Ohio will be repaid half by direct assessment on property in the district and half through tax levies on property of cities and counties. There was no federal or state assistance. The Muskingum Valley project is financed through PWA grant, federal contributions for navigation benefits, conservancy district assessments, and state grant. The state in addition relocated highways and roads wherever necessary, estimating that its benefits would be greater than the cost of that work.

A definite formula for federal participation in flood control work is set up in the Flood Control Act of 1936, as explained in another paper in this symposium.

In order to keep our economic system going along on as even a keel as possible, said Mr. Jacobs, we should provide against disasters that can humanly be avoided. Food control systems spell lasting benefits for industries, utilities, and private interests that will react to the good of the entire country.

Flood Conditions in New England

FLOOD CONDITIONS in New England were described by W. F. Uhl, M. Am. Soc. C.E., hydraulic engineer, Chas. T. Main, Inc., Boston. He gave particular attention to the floods of November 1927 and March 1936, both of which exceeded all records in their respective sections.

These two floods were caused by altogether different climatological combinations. The 1927 flood, largely confined to the state of Vermont, resulted from a tropical storm that was caught between two cold areas of high pressure. The ensuing torrential rain fell on ground already thoroughly saturated; it exceeded 9 in. over an area of 500 sq miles and 5 in. over an area of 22,000 sq miles—about one-third the area of New England. The 1936 flood was produced by an aggravation of the conditions that normally cause annual spring freshets. The preceding winter was one of average precipitation but lower than average temperature. A heavy snow blanket, light and powdery throughout its depth, lay over most of the area. Starting on March 9, there was a rise in temperature to somewhat above normal, coupled with heavy rains. In the next three days most of the snow cover in southern New England was melted, and the rainfall over an area of 1,400 sq miles was in excess of 5 in. Between March 9 and March 21, the total rainfall amounted at one station to almost 22 in., and the snow depletion exceeded an equivalent of 6 in. of water at a number of points. The greatest precipitation centered in the White Mountains near Mt. Washington, and traversed the headwaters of the Merrimack and the Saco and the west central part of the Androscoggin watershed.

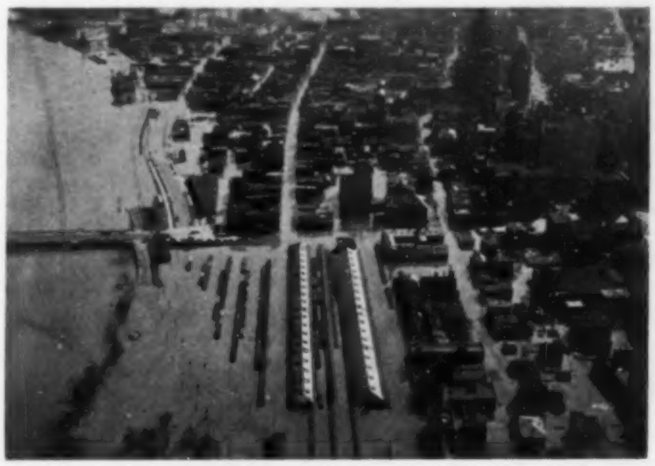
Based on 98 stations, covering the entire area of New England, the average temperature for March 1936 was 38.9 F, which is 6.5 deg higher than the mean for the past 49 years. Based on 178 records, the average precipitation for the same month was 8.04 in., which is 4.66 in. greater than the mean for the past 49 years and greater than any March on record.

More data are available on the 1936 flood than on any previous one. When it became evident that a major flood was about to occur, governmental and state agencies, utilities, and water power companies united to obtain as much information as possible. The Geological Survey was especially fortunate in securing discharge measurements at or near the peaks at many stations, thereby providing data for extending the rating curves.

The amount of damage caused by the 1936 flood has been investigated by a number of public agencies, and the work of gathering and tabulating these data is still in progress. The total damage is estimated at \$80,000,000, of which \$57,000,000 occurred in the Merrimack and Connecticut River valleys alone. In New Hampshire the loss amounted to about \$22 per capita; in Massachusetts, \$6.25.

Except for various local improvements, the possibilities for strictly economic flood protection on New England rivers other than by storage reservoirs are believed to be scarce. And if property damage alone is considered, said Mr. Uhl, the cost of reservoirs designed solely for flood control is in general far beyond the amount that can be economically justified. Of course, such possibilities are increased as we broaden our concept of the economics of flood protection by including considerations of public policy.

Economically, the most promising method of alleviating flood conditions in New England appears to be the construction of storage reservoirs for increasing the



THE CONNECTICUT RIVER PLAYS HAVOC WITH THE CITY OF HARTFORD—MARCH 22, 1936

low-water flow, and capable of serving the secondary purpose of reducing flood peaks. Storage reservoirs in this section are normally well down by October, and nearly empty by the end of the winter—the periods when floods are most likely to occur. Various authorities, after studying the effectiveness of existing power-storage reservoirs in reducing flood peaks, have recommended that the construction of additional reservoirs for power purposes be encouraged. The New Hampshire Water Resources Board has proposed four storage basins on the Merrimack watershed, to be built primarily to increase low-water flows and secondarily to reduce floods. The Army Engineers' Report on the Connecti-

cut River (1936) recommends an initial flood control plan comprising 10 reservoirs operated primarily for the control of floods and secondarily for the generation of power.

For specific cases, of course, reservoirs purely for flood control may be justified on ecomomic grounds alone. In Vermont, two such reservoirs have been built; they operated satisfactorily in 1936.

Mr. Uhl pointed out that an important factor in reducing flood losses is the proper issuance of flood warn-

West Springfield and Springfield, Mass., on the Connecticut River, During the March 1936 Flood

ings. The U. S. Weather Bureau is the formal agency in New England by which such warnings are issued; however, it is proper to question the adequacy of the service and to make suggestions for its improvement. Information concerning two factors is not generally available—the extent and water equivalent of the snow cover, and the condition of the ground beneath the snow. Such estimates, made by trained observers, are needed. As many private agencies now collect data on weather and flood conditions for their own use, Mr. Uhl suggested the setting up of a central forecasting agency to supplement the work of the Weather Bureau, or the expansion of that organization to correlate all the information collected by private and public agencies in order to give the public the benefit of all data available.

New York Floods of 1935 and 1936

A description of the unprecedented floods of 1935 and 1936 in New York was presented by Arthur W. Harrington, M. Am. Soc. C.E., and Hollister Johnson, Assoc. M. Am. Soc. C.E., respectively district engineer and hydraulic engineer, U. S. Geological Survey, Albany, N.Y.

In the period July 6–9, 1935, severe thunderstorms in south-central New York broke all one-day, two-day, and three-day official records of precipitation over an extended area. Unofficial records indicated 12 to 16 in. of rainfall in as many hours. Determinations by the U. S. Geological Survey indicated that streams with less than 5 sq miles of drainage area had maximum discharges exceeding 2,000 cu ft per sec to the square mile, or a peak runoff rate greater than 3 in. per hr over the drainage area. Streams with drainage areas up to 25 sq miles had maximum discharges in excess of 1,000 cu ft per sec to the square mile. These unit peak discharges were higher than any previously recorded in this region.

The abnormally heavy and intense precipitation caused

Such Losses Cannot Be Measured Adequately in Dollars
A Family in Owego, N.Y., Leaving Their Home as the Flood Waters Pour Through Windows and Doors

heavy erosion not only in small stream beds but even on smooth hillside surfaces. Much damage occurred in villages situated along small streams, where the encroachment of buildings and other structures restricted the channels and raised the water levels. Several cities in low-lying areas were inundated. Many bridge and culvert openings proved to be inadequate; fills were washed out and structures destroyed in many places.

About March 12, 1936, general but not unusual precipitation combined with warm weather and dense snow on ground extensively frozen, caused high stages on most of the streams, particularly in southern and eastern New York. The Tioga and Chemung rivers reached stages higher than those of the flood of July 1935. This storm left saturated soils, bank-full streams, and much snow in many sections. Between March 16 and 19, 1936, another storm with a precipitation of about 2 or 3 in. caused a second flood, with several of the streams in the Mohawk and upper Hudson River basins reaching higher stages than the preceding week and establishing new high records. About March 25–26, 1936, warm weather melted the snow left from the second storm and caused high but not record-breaking floods, principally on the Genesee and other streams in western New York. These three separate and distinct floods generally caused high-water stages for more than two weeks, with a very large total runoff, in some instances as much as 10 in. in depth over the drainage basins. Although notable flood stages occurred in eastern New York and in the Delaware and Susquehanna basins, flood conditions there were generally much less extraordinary than those in New England, Pennsylvania, Maryland, and some other regions.

The Sacandaga Reservoir, of the Hudson River Regulating District, practically empty at the beginning of March, stored without difficulty the entire runoff from 1,044 sq miles, and undoubtedly saved Albany from a repetition of the damages caused by the flood of March 1913. The computed maximum inflow into the reservoir was about 64,600 cu ft per sec during the flood of March 1936 as compared with a discharge during the flood of 1913 of about 35,800 cu ft per sec.

Two destructive floods within nine months have aroused an insistent popular demand for flood control in New York State. Some relief may be afforded by correcting channel conditions and enlarging bridge openings within reasonable limits, but the successful control of floods depends primarily on storage, the total capacity of which must be relatively large if floods similar to

those of July 1935 and March 1936 are to be substantially controlled. Storage reservoirs require natural sites, which are too often non-existent. Should not the public be afforded better information as to the limitations thus imposed by nature on flood control projects? Would it not in some cases, particularly in small villages occupying flood plains, be a more economical solution to purchase and remove some of the man-made obstructions to flood flows? May we be exceeding justifiable limits in designing to care for peak discharges as high as those of July 1935, which before that time had been generally considered impossible in New York? Flood protection involves a problem in engineering economics that may not always have been considered adequately.

These recent floods have emphasized the importance and value of basic data. We need more and better precipitation stations—stations equipped with recorders so that rainfall intensities can be studied. We also need more gaging stations. Since the best guide for the future is the experience of the past, long-continued records of precipitation and stream flow at an adequate number of strategic points will promote better preparation to meet future great floods as they occur.

The 1936 Flood in the Upper Ohio Basin

RESIDENTS OF Pittsburgh, checking over their flood losses of March 1936, may find some consolation in the thought that "it might have been worse." If the flood of February 28 and that of March 18, 1936, had happened to synchronize and produce one combined flood in the Allegheny and Monongahela rivers, the crest would have reached 54 ft instead of 46, stated E. K. Morse, M. Am. Soc. C.E., consulting engineer of Pittsburgh, and H. A. Thomas, M. Am. Soc. C.E., professor of civil engineering, Carnegie Institute of Technology. A height of 54 ft would also have been reached in 1927, if the rain storm of December 14 of that year had passed over the drainage area of the Monongahela and Allegheny instead of 40 miles to the west.

The average annual flood loss to Pittsburgh and vicinity, up to 1936, is estimated at $2,000,000. The annual estimated loss on the Ohio from just below Pittsburgh to Cairo (968 miles) is $100,000,000. The loss in Pittsburgh from the 1936 flood is estimated at $200,000,000, and this sum does not include loss of wages, loss of life and health, permanent damage to buildings and structures, or a multitude of miscellaneous items.

A GRIM DAY IN THE HISTORY OF PITTSBURGH
View of Stanwix Street from Duquesne Way, March 18, 1936

Perhaps $100,000,000 of this loss could have been avoided had an accurate forecast of the flood stage of March 18 been available on the preceding day. But the prediction on March 17 underestimated the crest by some 10 ft. Why was this error made, when 2 ft of packed snow lay in the mountains, a heavy rainfall was in progress, mild weather prevailed, and all the tributaries were raging torrents?

The fundamental reason is that the Weather Bureau office is financially starved. Consider, for example, the "Mad" Allegheny River. There are 12 observation stations along that stream for weather forecasts, and the observers are paid but $10 a month. There are 6 stations for reporting rainfall—and the observers receive 50 cents for every inch of rain reported! No Weather Bureau can make safe, intelligent weather and river reports under such conditions.

The time has long since come when salaried men of ability should be stationed along the headwaters of the Allegheny and Monongahela rivers, and every 50 miles from the southern Appalachian to the northern Allegheny mountains, equipped with modern appliances and local broadcasting outfits. The main office in Pittsburgh should have an emergency receiving station.

It is interesting to note that a reservoir in a drainage area downstream from Pittsburgh was of great indirect value to that city in the 1936 flood. A 6-in. additional rise in the Ohio would have flooded the Edison power plant at Winsor, which for days was Pittsburgh's only source of electrical energy. That rise was prevented by the Pymatuning Reservoir, which held back the peak discharge of the Shenango River until the crest of the Ohio flood had passed.

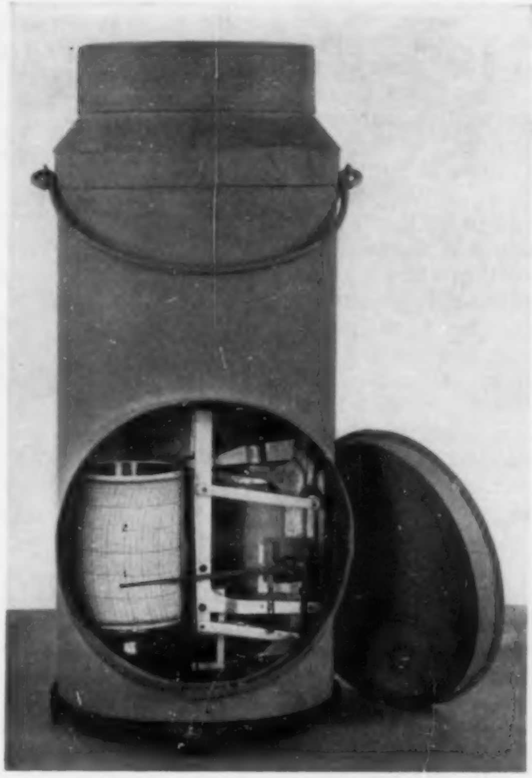
What have the City of Pittsburgh, the Commonwealth of Pennsylvania, and the federal government done to control and prevent the loss occasioned by floods? Between 1907 and 1934 the citizens of Pittsburgh and the commissioners of Allegheny County subscribed $250,000 for an exhaustive study of the situation. The state contributed $25,000, and the federal government a like amount, for a check survey by the Corps of Engineers, of the dams proposed by the Pittsburgh Flood Commission. In 1935 the Corps commenced construction of the Tygart River Dam, on a tributary of the Monongahela River. This structure is now nearly complete, and intensive work is in progress on the design of eight other dams in the Allegheny and Monongahela drainage basins.

An Ideal Organization for the River and Flood Service of the Weather Bureau

FLOOD FORECASTING on a systematic basis had its beginning in France in 1854, according to the late Montrose W. Hayes, chief of the River and Flood Division of the U. S. Weather Bureau. Italy and Bohemia followed in 1866, and the United States in 1871, the latter date being one year after the establishment of the national weather service.

In making flood forecasts today, the U. S. Weather Bureau employs two systems. The one that is the older and more refined is forecasting from river-gage relations and discharge data. The second is forecasting largely or altogether from reports of rain that has fallen or is expected to fall.

The first system, forecasting from river-gage relations and discharge data, can be used at places two days



A Recording Rain Gage

or more distant from the regions in which the flood-producing rains occurred. This system is satisfactory, as the term of the forecasts ranges from two or three days in the upper valleys to as much as three or four weeks in the lower Mississippi basin.

Forecasting floods from rainfall data is practiced near the headwaters of streams, where the flood water is collected from innumerable channels, many of which are water carriers only during heavy rains. These channels cannot be gaged economically, and formulas for making predictions must be developed solely through a knowledge of the amount of rain that has fallen and the areas that it has covered.

The demand for river-stage and flood forecasts has grown rapidly, especially in the last few years, on account of the development of streams for power, navigation, and irrigation; the larger consumptive use of water by growing cities; and the greater use of the flood planes of rivers by industry. Also, contrary to public opinion, the successful operation of flood control works, as well as their construction, requires forecasts of ice-forming weather, of impending rains, and of floods.

The standard of refinement of flood forecasts is set by those who use the forecasts. If the interests along a river can be protected by a two-day forecast verified in stage with an accuracy of about 2 ft, it would be useless to spend the money necessary to provide a three-day forecast with an order of accuracy of less than 0.5 ft.

Adequate Flood Forecasts Depend Upon a Network of Installations Like This, Intelligently Manned

A Typical Station for Rainfall and Temperature Observations

Users of flood forecasts are now demanding a greater refinement and longer-term predictions, owing to the unprecedented heights of, and the great loss caused by, the floods of March 1936. To meet the demand, changes in the present plan of operation will be necessary and some outstanding deficiencies must be met, among them being the following:

1. Establishment of more and better-placed rainfall stations, especially in headwater regions.

2. Installation of an adequate network of recording rain gages to enable the forecaster to know the intensity of the rainfall.

3. Surveys of the amount and condition of snow in the eastern mountains, from which little information concerning snow is now available.

4. Arrangements for a more reliable transmission of rainfall and river-stage reports from the substations to the district centers. In the eastern floods of March 1936, the failure of wire communication was almost entirely responsible for any lack of timeliness and accuracy in the warnings issued. Except in very unusual cases, the telephone and telegraph wires answer all purposes with a great degree of satisfaction, but in the unusual cases, which are emergencies, the greatest need for the reports exists, and a river forecaster without information from the drainage area above him is helpless. The problem is difficult to solve, but some solution will be found, probably by using amateur radio operators, or by placing a number of substations on good highways so that reports can be taken by automobile to the nearest points for forwarding by wire.

5. Work at the Weather Bureau stations has grown so much and the personnel have so many and such varied duties, that it is impossible to perform the necessarily deliberate and protracted work of developing flood-forecasting formulas and keeping them up to date. This can be overcome by providing specialists in flood forecasting for all the important basins of the country. A plan of this kind has already been put into effect in a very small way. A few men have been placed both in the Missouri Valley and in the upper Mississippi Valley, and other parts of the country will be taken care of as it becomes possible to do so.

Federal Plans for Flood Control

Recent heavy flood losses have aroused the country as never before to a realization of the importance of flood control measures, said W. E. R. Covell, Lieutenant Colonel, Corps of Engineers, U. S. Army, District Engineer, Pittsburgh, Pa. Colonel Covell's paper presented a general outline of federal flood-control activities in this country since their inception.

Early land grants along the Mississippi River, he said, required the grantee to construct and maintain a levee line along the river front of his property. Despite the levees thus constructed, however, the floods of 1849 and 1850 did so much damage that national interest was aroused. As a result, the Swamp Land Act was passed in 1850. A number of river surveys were made in the following years, and the Mississippi River Commission was authorized by Congress in 1879.

Although the commission expended large sums for

levees between 1890 and 1917, the work was done primarily in the interest of navigation. Flood control as such did not become a definite part of the work of the Commission until the latter year. The Flood Control Act of 1917 provided for cooperation by local interests, they to provide the rights of way, pay not less than one-third the cost of levee construction, and assume the entire cost of maintenance.

In 1927 the lower Mississippi experienced the highest flood of record, and the following year saw the adoption of the "Jadwin plan" for control of that stream. Cooperation by local interests was made mandatory by the Flood Control Act of 1928, the basis for participation being similar to that provided in the Act of 1917.

The first expansion of federal interest in flood control to other parts of the country appeared in the Flood Control Act of March 1, 1917, which resulted in a general project for flood control for the Sacramento River, in California. The state was required to share equally with the federal government in the cost of the works, and in addition to provide all rights of way and easements without cost to the government.

Federal interest in river planning of wide scope was manifested in 1925, with the authorization of the now famous "308" reports. These studies, conducted by the Corps of Engineers, U. S. Army, and but recently completed, covered practically all the principal drainage systems of the United States. Plans for the orderly development of the streams were presented, consideration being given to power, irrigation, and navigation possibilities as well as to flood control. These reports furnished the basis for many of the projects authorized by the Flood Control Act of 1936.

That piece of legislation marks the first adoption by law of a federal policy with respect to flood control. It recognizes that destructive floods constitute a menace to the national welfare, and that flood control on navigable waterways or their tributaries is a proper activity of the federal government in cooperation with states and political subdivisions, if the benefits, "to whomsoever they may accrue," exceed the estimated costs, or if life and social security are otherwise adversely affected. Flood control studies and projects are placed under the jurisdiction of the War Department, and soil erosion control and similar activities are assigned to the Department of Agriculture. The states or other responsible local agencies must provide all lands and easements necessary for the construction of projects authorized by this Act, within certain limits, and must maintain and operate all the works after their completion. Interstate compacts are authorized, subject in general to specific ratification by Congress.

Pursuant to this policy, the Act authorizes 219 main flood-control items in 46 major basins and localities throughout the country, and preliminary examinations and surveys for flood control in 222 localities. It further authorizes the appropriation of $310,000,000 for these projects, not more than $50,000,000 of which may be expended during the current fiscal year.

The projects for the Ohio River basin, according to Colonel Covell, include (1) a reservoir system to protect Pittsburgh (Fig. 1), and (2) a reservoir system for the reduction of Ohio River floods below Pittsburgh. The first of these projects consists of 9 units, not including the Tygart River Reservoir, now under construction. The system may be considered tentative; revision of the "308" studies by bringing them up to date may indicate that additional reservoirs or other facilities may be economically justified. Preliminary studies indicate that this system would have reduced the stage of the March 1936 flood at Pittsburgh by 7 ft. Its total cost, excluding the Tygart Reservoir, is estimated at $55,215,000, of which $34,569,000 is for land and damages. It is evident that the Allegheny-Monongahela basin does not represent virgin territory in which reservoirs may be provided at favorable physical locations without great cost.

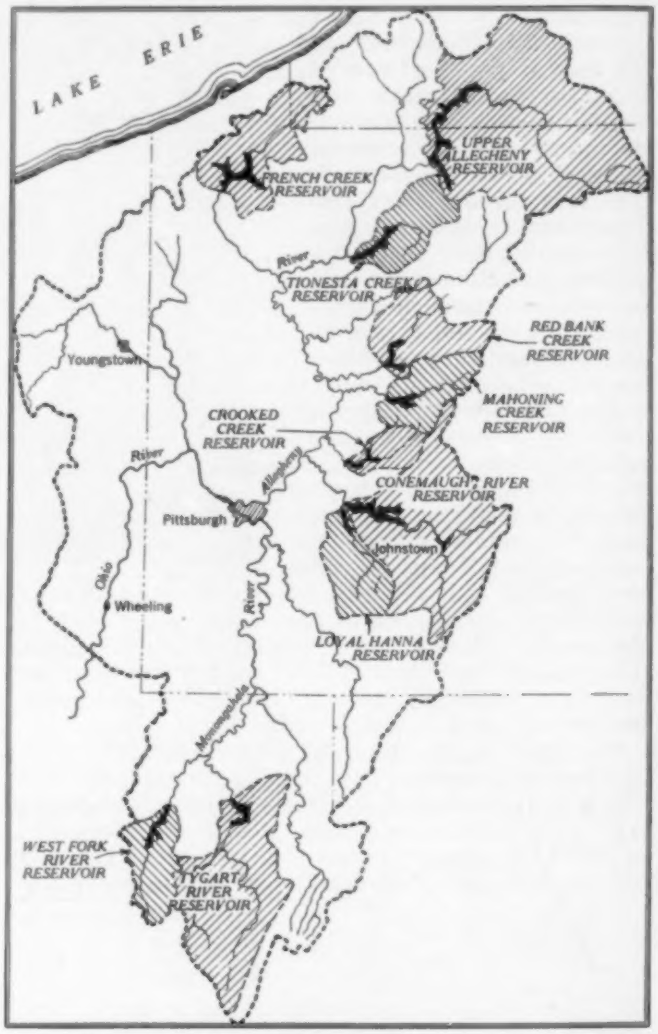


FIG. 1. TENTATIVE SYSTEM OF RESERVOIRS FOR THE PROTECTION OF PITTSBURGH

Cross-Hatching Indicates the Drainage Area Tributary to Each Reservoir

The second project comprises these same 9 reservoirs and 5 others—3 on tributaries of the Kanawha, and 2 on the Licking River, which enters the Ohio opposite Cincinnati. At one of the reservoirs in the Kanawha basin (the Bluestone) power production can apparently be combined with flood control. The cost of the development at this site, including power installation, is put at $13,000,000. The other four reservoirs are estimated to cost a total of $17,194,000. This system of 14 reservoirs, together with the system now under construction in the Muskingum watershed, may be expected to reduce the peak of a great Ohio River flood similar to that of 1913 by 7.5 ft at Pittsburgh, 3 ft at Cincinnati, and about 6 in. at Cairo. Lesser floods would in general be reduced to a greater degree. The direct annual benefits of this protection were estimated, prior to the 1936 flood, to be less than the annual carrying charges on the proposed system.

State Systems of Plane Coordinates

The Theory and Commercial Application of State-Wide Grid Systems

BEGUN in North Carolina by the U. S. Coast and Geodetic Survey at the request of local engineers, individual systems of plane coordinates have now been worked out for all the various states. Descriptions of the methods used in establishing such systems, and in using them as a check on a commercial survey, form the subject matter of two addresses delivered on October 14, 1936, before a session arranged by the Surveying and Mapping Division and the Pittsburgh Section as a part of the Society's Pittsburgh Meeting. Abstracts of both of these papers are here presented for the information of members.

Two different methods of map-making were used as the bases of the various systems—the Lambert conformal conic projection for states having their greatest length from east to west, and a modified transverse Mercator projection for those of maximum dimensions in a north-south direction. A discussion of the theory involved occupies the larger part of Mr. Adams' article. In the second paper, Mr. Yoder shows how such a system proved of value in providing a tie-in for a triangulation survey of a 100,000-acre area in the coal region of West Virginia. The articles on this important subject in a sense are complementary.

Development of State Grid Systems

By O. S. Adams

Senior Mathematician, U. S. Coast and Geodetic Survey, Washington, D.C.

AT the present time the nation-wide network of arcs of triangulation established by the U. S. Coast and Geodetic Survey has a total length of some 65,000 miles. These arcs, which are fairly evenly distributed throughout the country, thus form the basis for the control of further surveys that may be made locally or regionally wherever the data are readily accessible. Experienced engineers and surveyors realize the fundamental importance of rigid checks on any observational data. In an independent survey certain checks may be afforded by the methods of observation, but in a subsidiary survey, an external check is of the greatest importance. This can be made by means of work that has already been established and shown to be correct by various checks in the net to which it belongs.

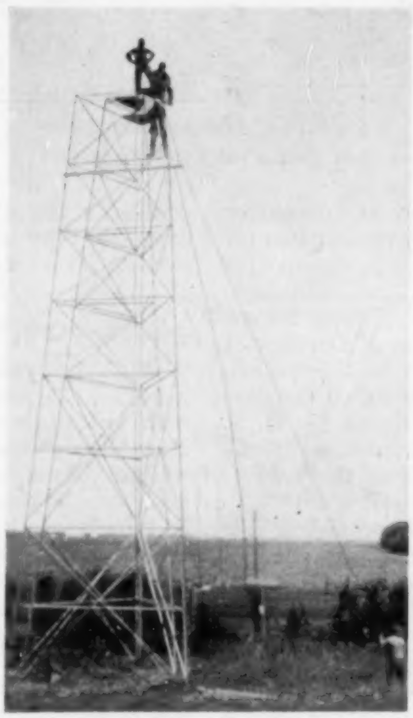
Much remains to be done in establishing these fundamental federal surveys, in spite of the fact that during the past few years there has been a rapid expansion of the horizontal control net of the nation. There are large areas not yet supplied with the fundamental data. The rapidity with which the national net may be completed will depend almost entirely upon the demands made on the federal government by engineers, planners, and others who may require horizontal-control survey data in the execution of their work.

OTHER BUREAUS EXTEND SURVEYS

In addition to the data established by the Coast and Geodetic Survey, there are many surveys that have been made by other bureaus of the government, such as the Geological Survey and the Corps of Engineers of the Army. Whenever these surveys are properly tied in with the fundamental net of the Coast and Geodetic Survey, showing an error of closure acceptable for first-, second-, or third-order surveys, as the case may be, they in turn may become control data for subsequent work. In sum total, therefore, there exist, scattered fairly evenly over the country, many thousands of stations that are accurately located and correlated with one another.

In view of this fact, it is of supreme importance to arouse the interest of engineers and surveyors throughout the country to the great advantages of basing local and regional surveys on this fundamental control. Since this control net is so extensive, reaching from one end of the country to the other, it is necessary in the computations to take into account the curvature of the earth. Consequently the final data are expressed in terms of latitude and longitude, and in azimuths and lengths. As such geodetic computations are rather involved, some study is usually required before they can be made with ease and certainty even by well-trained engineers and surveyors. The actual computations are not very difficult, but the mathematics involved in the basic theory is beyond the grasp of many who wish to understand fully the significance of the computations.

The Coast and Geodetic Survey tried for fifty years, more or less, to encourage among the engineering profession the use of control surveys in the form of geodetic positions. While in certain instances this effort met with success, on the whole it did not. Many were needlessly frightened off by an exaggerated view of the difficulties to be encountered, and so the bureau changed its tactics



It Is Generally Necessary to Use Observing Towers at the Main Stations of the Survey's Triangulation Arcs

and sought to attain its objective in another way.

During 1932 and 1933, the Coast and Geodetic Survey cooperated with North Carolina in the completion of the first-order horizontal control in that state. Early in 1933, George F. Syme of the North Carolina Highway

FIG. 1. INDEX MAP OF OHIO, SHOWING PLANE-COORDINATE ZONES Established by Use of the Lambert Conformal Conic Projection

and Public Works Commission requested us to consider setting up a system or systems of plane coordinates for the state. (Mr. Syme's article on "Geodetic Control for North Carolina Highways" appeared in CIVIL ENGINEERING for March 1932.) At the request of William Bowie, M. Am. Soc. C.E., chief of the Division of Geodesy, I undertook a study of the possibilities for such a system. While working on this project, I had several conferences with C. H. Birdseye, M. Am. Soc. C.E., of the U. S. Geological Survey, who was much interested in the subject. As a result of my study and of the various conferences, a plane-coordinate system was devised.

Not long after the tables had been completed, the tragic death of Mr. Syme occurred. The direction of the work then passed into the hands of O. B. Bestor, M. Am. Soc. C.E., who has been carrying on local survey operations using the coordinates of the triangulation stations in the state system as control. Several thousand miles of traverses have already been run and computed on the plane with no greater complications than those involved in latitudes and departures.

The computation of tables for state-wide systems of plane coordinates was thus undertaken at the request of a practical engineer and surveyor. The incentive for the initiation of all such schemes came similarly from engineers outside the government departments rather than from mathematicians and geodesists.

For the North Carolina system, the Lambert conformal conic projection with two standard parallels was chosen as a basis. A conformal projection was employed because the angles are better preserved in this class of projections than in any other class. By holding the scale exact along two standard parallels, it is quite possible to keep the departure from true scale within a prescribed maximum for a much wider strip of country. In computing tables for the reduction of geodetic positions to plane coordinates, the work was confined to the elements necessary for such reductions. No table of meridian and parallel intersections was computed because it was planned that the Coast and Geodetic Survey should compute the plane coordinates of all the stations in the control net and have these available as well as the geodetic positions. The engineer or surveyor would then have nothing more to do than to make use of the computed coordinates in his work.

The Lambert projection is suitable for a state having its greatest extent from east to west (Fig. 1), since it can be extended almost indefinitely for this purpose. On the other hand, its extent from north to south must be kept within a limit of 158 miles, if the departure from true scale is to be kept within one part in 10,000.

DIFFERENT PROJECTION USED FOR NEW JERSEY

After the system for North Carolina had been established, we began a study to see what could be done for a state having its greatest extent from north to south, and New Jersey was chosen for this purpose. Since we wished to make use of a conformal projection again, after careful consideration we decided to apply a modified form of the transverse Mercator projection. To apply this projection rigidly, it would be necessary first to map the ellipsoid on the conformal sphere and then to map that sphere on the plane. We wished to hold the scale constant along the central meridian of the region to be mapped; however, this could not be done without introducing some slight departures from full rigidity. Investigation showed that for the limited region to be mapped, a satisfactory solution might be found by adapting our formulas for geodetic positions to the calculation of the elements required for computing the coordinates.

An explanation of the entire process will not be attempted, but an idea of the theory involved may be obtained by thinking of the ordinary Mercator projection with which most engineers are familiar. Let us suppose that a zone of 79 miles on each side of the equator is mapped on an ordinary Mercator projection. Then, if the scale along the equator is reduced by one part in 10,000, the resulting map will have a scale too small along the equator and too large by an equal amount along the top and bottom. But it will also have two parallels at certain locations equidistant from the equator along which the scale will be exact. Now if we think of the great circle from which the surface is mapped as being a meridian instead of the equator, we shall have a true picture of what is done (Fig. 2). Unfortunately for our purposes, the earth is not, of course, a true sphere; and the meridian is an ellipse, not a circle. However, with slight sacrifice of conformality the ellipticity can be neglected, and our purpose is attained for the small area that is to be included in any one system. For details reference may be made to the article by Philip Kissam, Assoc. M. Am. Soc. C.E., "New Jersey Adopts Plane-Coordinate System," in Civil Engineering for November 1935.

We found that this system gave a satisfactory solution for New Jersey. Accordingly, tables were prepared for that state and satisfactory formulas devised for the reduction of geodetic positions to coordinates.

We had thus developed two systems of conformal projections that are admirably suited as bases for plane coordinates—the Lambert projection for regions having their greatest extent from east to west, and the transverse Mercator projection for those with greatest extent from north to south.

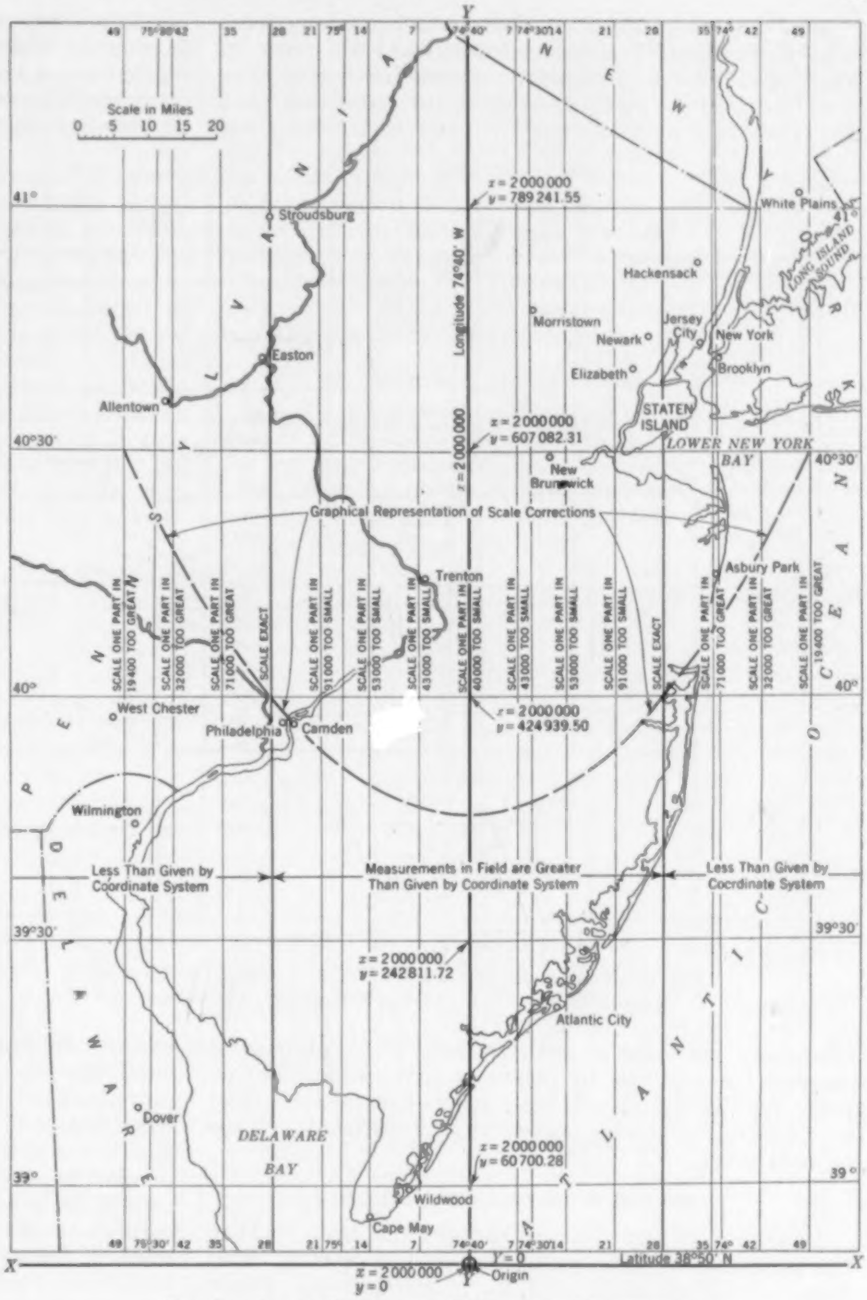


Fig. 2. Plane-Coordinate System for New Jersey
Based on a Modified Transverse Mercator Projection

Systems Extended by CWA

Soon after we had reached this point in our investigations, the Civil Works Administration program was launched. As the need for such plane-coordinate systems for all the states was apparent, the computations were expedited and systems for the 48 states were completed early in 1934. In Fig. 3 are shown some of the CWA traverses in Nebraska.

As previously stated, it is the plan of the Coast and Geodetic Survey to reduce all the stations on these systems from geodetic positions to plane coordinates. After these computations have been completed, the resulting coordinates will be made available for distribution either in the state triangulation and traverse publications or in the form of lithographic reproductions. Up to the present time publications for the states of Tennessee, California, and Minnesota have been issued containing both the geographic positions and the plane coordinates of the stations. For several other states all the computations are ready for publication but the necessary funds are lacking.

In all the arcs of triangulation that have been observed since about 1927, there is established at each main station an azimuth mark distant a good fraction of a mile from the station and visible from the ground at the station. As the main stations of such arcs are seldom intervisible from the ground, it is generally necessary to use observing towers for them; consequently the azimuth marks are of great help in using the control for local or regional surveys. The geodetic azimuth of the mark from the station is first determined. In the plane-coordinate computations, this geodetic azimuth is then reduced to a plane or grid azimuth for use in local plane surveys. Such grid azimuths are later given in the lists of plane coordinates in order that the surveyor may have all the data necessary for the control of his work.

After the coordinates of the control stations have once been computed, it makes scarcely any difference on which of the two projections the computations may have been based, as the methods of using the coordinates and the computation of surveys by plane coordinates are

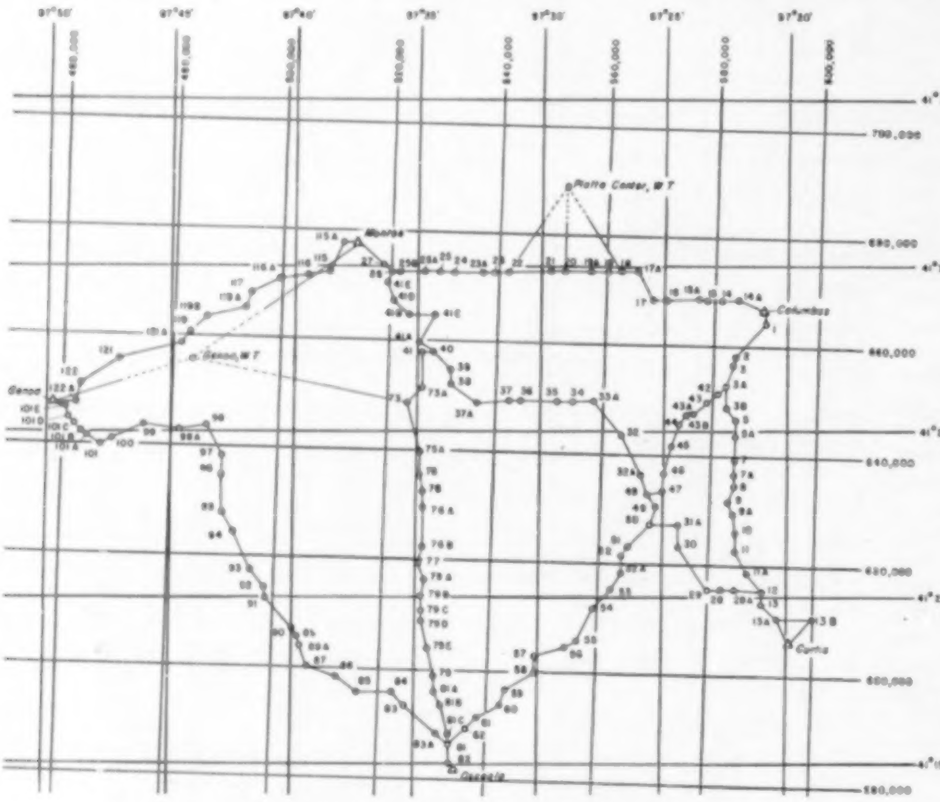


FIG. 3. TRAVERSES MADE BY CWA IN VICINITY OF COLUMBUS, NEBR., SHOWING GRID LINES, MERIDIANS, AND PARALLELS

essentially the same in both systems. The method of traverse computation by means of latitudes and departures, familiar to all who have studied plane surveying, is in general use among surveyors and engineers in some form or other.

ERRORS INVOLVED ARE SMALL

In almost all the systems, the aim has been to keep the variations of scale within one part in 10,000. This limit was slightly exceeded in the North Carolina system because the engineers there preferred to let the departures exceed this limit rather than have the state divided into two zones. In the computation of third-order traverses, it is probably not necessary to take into account these variations in scale. In more accurate work, however, it is advisable to correct the measured lengths before computing a given traverse.

Since in both systems the reductions to coordinates are made from geodetic positions, sea-level lengths are involved at the start. Accordingly two separate reductions should be applied to measured lengths before they are employed in the computation of a traverse, if the most accurate results are required. The lengths should first be reduced to sea level, and a correction should then be applied for the variations of scale on the grid.

These variations are listed for every minute of latitude on the Lambert grids and for every 5,000-ft distance from the central meridian on the transverse Mercator grids. By use of the tables the grid correction for any given line may thus be determined very readily. In most cases it is sufficiently accurate to determine a mean correction for any given traverse. For a traverse that is properly tied in with the control, there will be a first station and a last station for which the coordinates will be given. By consideration of these coordinates it is very easy to determine from the coordinate tables just what mean grid factors may be required for the measured lengths of the traverse in question.

A number of the states have already made very extensive use of the coordinates in their local work. In North Carolina the use of the grid was started at once, and it is still being actively used for all local surveys under the direction of Mr. Bestor. In New Jersey the system has been used extensively in the computation of local traverses, and under the able direction of Prof. Philip Kissam, of Princeton University, a law has been passed that legalizes the definition of property boundaries in terms of the coordinates of the angle points of the property. This is a significant improvement both in the interest of the coordinate system and in that of cadastral surveying in the state, and forms an important advance in the method of defining property boundaries.

SOME ADVANTAGES OF THE SYSTEM

In Tennessee the coordinates are in wide use by the various divisions of TVA. Traverses are being computed directly on the grid, and the corners of all property purchased by the government are being tied in with the state system of control, thus fixing for all time the exact location of such points. Monuments, even of the most permanent type, may be destroyed in time. Even though at some future time the marks at any of the corners should be destroyed, the coordinate relations will still persist and the actual site of the monument can be relocated and remonumented.

Extensive use is being made of the coordinate system in North Carolina, South Carolina, Georgia, Florida, Alabama, Tennessee, Louisiana, New Jersey, Connecticut, Massachusetts, Iowa, and many other states. A topographic map of the city of Denver and vicinity, being made under a WPA appropriation, is based on the Colorado grid.

The matter of city surveys brings up the question of sea level versus ground level, that is, whether a grid scale or a mean ground-level plane should be used. A circular letter was sent out to a number of representative engineers and surveyors to get a general recommendation on this point. Most of those who replied looked at the matter in the same way we did—that is, they felt that the importance of having the work tied in with the control net far outweighs the need for exact ground-level distances. Actual lengths and areas can easily be determined from a map made on the state grid even though the coordinates may give slightly different results. It would only be necessary to multiply the grid lengths by a certain factor given in the table and to

increase or decrease the area of any given plot by twice the mean linear departure from true scale for the given region. Denver is probably at a higher elevation than any other large city in the country and, if the state grid is found sufficiently satisfactory there, it should be more so for any other city in the country.

It is our opinion that all local surveys consisting merely of traverses can be computed on these state-wide plane-coordinate grids with much less effort than would be required by any other method. If, however, a local survey is carried on by means of triangulation, it is probably simpler and more economical to compute the work geodetically, since the calculations required for the use of the grid are equal to if not greater than those necessitated by the geodetic method. Indeed, we would not desire to discourage any engineers or surveyors even if they wish to compute all their work geodetically, provided only that they base their work on federal control surveys. They would be overlooking a great advantage, however, in failing to use the grid for their traverse computations.

The Corps of Engineers, U. S. Army, is becoming much interested in the state grids and is actually using them in some sections. No doubt the Corps would use them much more extensively if stations of the control surveys were more accessible in the regions in which it is carrying on work. It is hoped that arcs of triangulation may soon be observed along the principal rivers of the country. Such arcs would then serve as bases for the more detailed surveys of the Corps.

At the instance of Professor Kissam, the Federal Board of Surveys and Maps appointed a subcommittee on control to study the advisability of the board's giving its approval to the use of state-wide plane-coordinate systems. After an exhaustive study of the matter, the subcommittee presented a report to the full committee on control, recommending approval of the use of state grids, whenever practicable, both by federal bureaus and by private engineers and surveyors. The report of the committee, as presented at the meeting of the board on September 8, 1936, was approved and adopted. An added impetus has thus been given to the use of this tool which we believe to be very important to the engineering profession, tending, as it does, to increase the accuracy of local surveys and make them of service in turn to other surveys in the vicinity.

INFORMATION FURNISHED ON REQUEST

The Coast and Geodetic Survey has issued three special publications on the subject of the theory and use of the coordinate systems. These publications, which may be obtained at a nominal price from the superintendent of documents, Government Printing Office, Washington, D.C., are designated as Special Publications Nos. 193, 194, and 195. The first is a general treatise applying to both systems. Each of the other two applies to only one system—No. 194 to the Lambert Grid, and No. 195 to the transverse Mercator grid. For any further information about the plane-coordinate systems and their use, or about the subject of projections in general, application should be made to the director of the Coast and Geodetic Survey, Washington, D.C. Any available information will be gladly furnished on request, as this important phase of geodesy is destined to become even more important in the future than it has been in the past.

Coordinates Aid Survey of Fairmont Region

By L. E. Yoder

Civil and Mining Engineer, Consolidation Coal Company, Inc., Fairmont, W.Va.

In the West Virginia coal field in the vicinity of Fairmont, Marion County (Fig. 1), a substantial and comprehensive survey system was required for coal properties covering approximately 800 sq miles of area. This was accomplished by means of a triangulation survey. The area covered is that part of the Monongahela River watershed extending from Clarksburg to Morgantown, W.Va. In this area the Consolidation Coal Company has interests covering 100,000 acres. There are over 200 triangles in the net, shown in part in Fig. 2. The terrain, which consists of hills rising from 1,200 to 2,200 ft above sea level, and from 400 to 1,200 ft above the river bed, was admirably adapted to triangulation. In no case was it necessary to erect a tower to obtain sights.

The U. S. Geological Survey also uses the triangulation method to map the terrain, and some features of its work require refinements because of earth curvature, convergency of meridians, and reduction of units of length to sea level. The Fairmont triangulation system has been attached to, and compared with, the Geological Survey triangles in an interesting way.

The Fairmont area was laid out in a system of grid squares. All meridians and parallels in the local system are respectively parallel, whereas the meridians of the Geological Survey system converge to a point at the north pole. The primary meridian of the local system coincides with the geodetic meridian. The intersection of the primary meridian with the primary parallel of latitude is the origin of coordinates, and all points within the grid are designated by an abscissa and ordinate in feet with reference to the point of origin, as shown in Fig. 1. The position of survey stations within the system and of points in the mines far below the surface are fixed by their coordinate distances from the origin.

The necessity for such accuracy may be appreciated by the fact that the coal measures in the field overlie highly productive oil and gas sands. More than 2,000 gas and oil wells are drilled through the coal operated by one company, and in some instances the wells are very close to one another. It is of course highly important that the mine working should avoid such dangerous hazards as driving into an oil or gas well. It is also necessary to guard against driving into neighboring mines, especially if they should contain large bodies of water or gas. The following paragraphs describe the methods used in the survey, the degree of accuracy attained, and the commercial value of the results.

SURVEY STARTED IN 1893

The triangulation work was started in 1893 by George F. Duck, a mining engineer for a small group of mines that were later merged with the Fairmont Coal Company and finally the Consolidation Coal Company. Mr. Duck had established one triangle, the nucleus of the system, to control the line surveys of the mine properties. The work

had been carefully done, but some refinements were found necessary when the net was expanded in 1902 by Herman G. Hessee, who succeeded Mr. Duck. The establishment of the meridian by Polaris observation was found to have been accurate within 20 sec. The base-line measurements had not been compensated for sag or temperature, nor was the tape which had been used

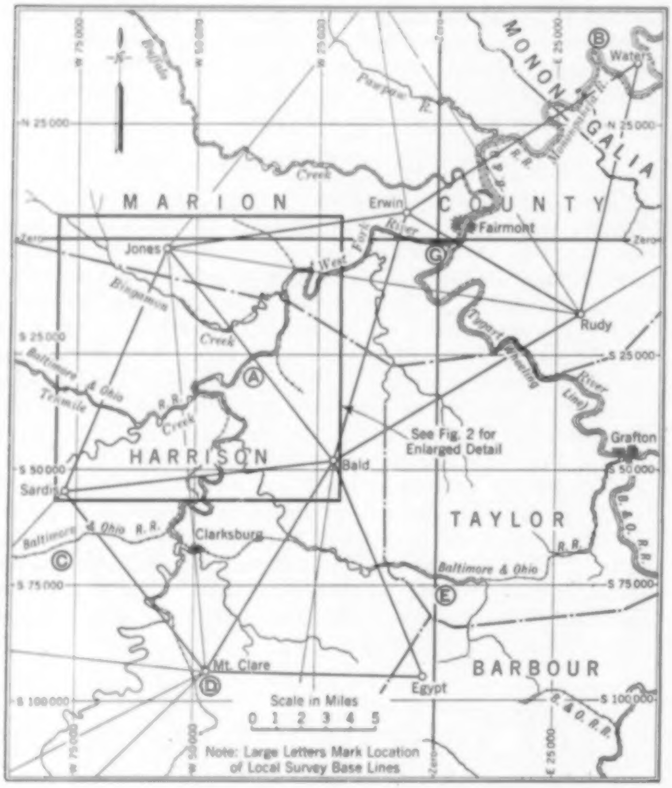


FIG. 1. MAP OF FAIRMONT COAL REGION IN WEST VIRGINIA
Showing Grid Squares of Coordinate System and the U. S. Geological Survey Triangles to Which the Consolidation Coal Company's Survey Was Tied

known to be standard. The meridian as originally established has been maintained, but the primary triangle was adjusted after measuring the newly established bases. The survey was eventually completed in 1907.

The angles were measured with a 6-in. transit, graduated to read direct to 30 sec. Angles were sometimes estimated to 5 sec, though usually not finer than 10 sec. The base lines were with one exception measured with a special steel tape, somewhat over 300 ft long and $^1/_8$ in. wide, with graduations etched every 5 ft. Comparison was made by the manufacturer with a similar tape of the U. S. Coast and Geodetic Survey at Washington, and the special tape was then certified as correct at a tension of 8 lb and a temperature of 62 F, when supported throughout its entire length. Upon its receipt from the manufacturer, the tape was sent to the Bureau of Standards, checked in 100-ft lengths, and verified.

A standard spring balance was used to apply the desired tension, and a standard mercury thermometer to register temperatures. Stations were marked by sections of steel rail weighing not less than 65 lb per yd and not less than 42 in. in length, driven flush with the surface and then center-punched.

MEASURING BASE LINES

There were six base lines, including the Gaston base of the primary triangle. The Gaston base, which is marked *G* in Fig. 1, had not been fully compensated, and so has been used only as a check. Four of the bases are at the extreme ends of the several branches, and one at the approximate center of the system. They are located along railroad tangents and their extreme ends are marked by steel rails similar to the other stations. The center base, which is the fundamental base of the system, measured 1,132.4428 ft. It is designated on the maps by the letter *A*. The other bases are designated by the letters *B*, *C*, *D*, and *E*.

Bases were measured after sundown on calm days, at temperatures as close to 62 F as possible. The work was done by a party of five men: One recorded notes; one read temperatures; two held the tape; and one read measurements. The tape was supported on line by stakes spaced at 50-ft intervals, driven to grade. The stakes at 300-ft intervals were capped by zinc, scored by a fine line to mark the measuring point. The grade angle between the ends was determined by precise levels. Each observer made two independent readings of the entire base at tensions of 8, 10, 12, 14, and 16 lb, respectively. Each of the five members of the party took his turn as observer, so that there were in all 50 measurements, and the mean of the reductions was accepted as the length of the base.

Four corrections were made to observed measurements, as follows:

1. Correction for temperature $= +C\,(T - t)\,L$
2. Correction for tension $= +S\,(P - p)\,L$
3. Correction for catenary $= \dfrac{L}{24}\left(\dfrac{Wd}{np}\right)^2$
4. Correction for slope $= \sqrt{L^2 - h^2}$

An explanation of the various symbols used in these formulas follows:

L = observed measurement
C = (0.0000063) coefficient of expansion
S = (0.000013645) coefficient of elasticity
p = (8 lb) standard tension
P = observed tension
t = (62 F) standard temperature
T = observed temperature
d = distance between supports
n = number of intervals between supports
W = (0.009375) weight of tape, pounds per lineal foot
h = difference in elevation between ends, in feet

ANGLES MEASURED EIGHT TIMES

Angles were measured in the following manner: With the telescope normal and verniers set approximately at zero, a sight was taken on the left-hand station and the angle *A* measured clockwise.

Unclamping the lower motion and repeating the measurement three times, the accumulated angle was divided by 4 for the first value of *A*. The angle was then measured four times in a counterclockwise direction, with the vernier set at 90 deg approximately and the accumulated angle divided by 4 for the second value for *A*. The third and fourth values for *A* were determined with the vernier set approximately at 180 and 270 deg, and the angles measured in clockwise and counterclockwise directions, respectively. Then, with the telescope inverted, four more values were determined by repeating the operations already outlined. The mean of the eight values was taken as the tentative value of the angle.

This procedure required the reading of each angle 32 times. It was found that with few exceptions triangles closed within 5 sec. When closures exceeded this amount, the angles were remeasured. Closure error, plus or minus, within the 5 sec was distributed in proportion to arbitrary weights assigned to each angle, according to

circumstances affecting the observations. Angles were also weighted according to their factors in closing quadrilaterals.

All calculations were made by two computers who checked each other. The triangles were solved by sine ratios, using the natural tables to seven decimals and carrying all results to the ninth significant decimal. The computations involved laborious effort, which may be hard to appreciate today in view of modern calculating devices.

After completing the central series of triangles, which followed the Monongahela River, two additional chains were run parallel with, and approximately 5 miles distant from, the center chain. The three groups were joined at their north and south ends.

The traverse closure error of the east chain with the center was 1.86 ft in latitude and 0.60 ft in longitude. The traverse distance being 176,800 ft, the error was thus about 1 in 100,000. The traverse closure error of the west chain with the center was 3.44 ft in latitude and 3.89 ft in longitude, which, with a traverse distance of 211,200 ft, gave an error of about 1 in 61,000. The coordinates of the stations in the east and west groups were adjusted to absorb the closure errors in proportion to their respective longitudes and latitudes.

As previously stated, Base *A* measured 1,132.4428 ft and formed the fundamental of the system. Closures of the other base lines were as follows:

Base *B* (Distance *A-B* = 99,985.27 ft)		Base *D* (Distance *A-D* = 68,073.94 ft)	
Measured	1,250.4004 ft	Measured	1,200.6641 ft
Calculated. . . .	1,250.4028 ft	Calculated. . . .	1,200.3060 ft
Difference	0.0024 ft	Difference	0.3581 ft
Base *C* (Distance *A-C* = 53,935.60 ft)		Base *E* (Distance *A-E* = 60,810.21 ft)	
Measured	1,200.9677 ft	Measured	1,500.1232 ft
Calculated. . . .	1,200.9285 ft	Calculated. . . .	1,499.8404 ft
Difference	0.0392 ft	Difference	0.2828 ft

While these results indicated that the accuracy consistent with requirements had been attained, there remained an academic interest in determining how the system checked with the U. S. Geological Survey. Accordingly, the stations of this survey were incorporated at convenient points, and a comparison made (1906) as shown in Table I.

CAREFUL METHODS USED THROUGHOUT

When the circumstances require great accuracy, the same degree of care must be exercised in all parts of the work. It is important that all the notes, calculations, and traverses be referenced and indexed so as to be readily accessible when required.

Field notebooks, calculation books, and traverse folios are assigned to definite areas within the field. A separate group of books is provided for each class of survey, and surface surveys, mine surveys, levels, and construction data are written in their proper books.

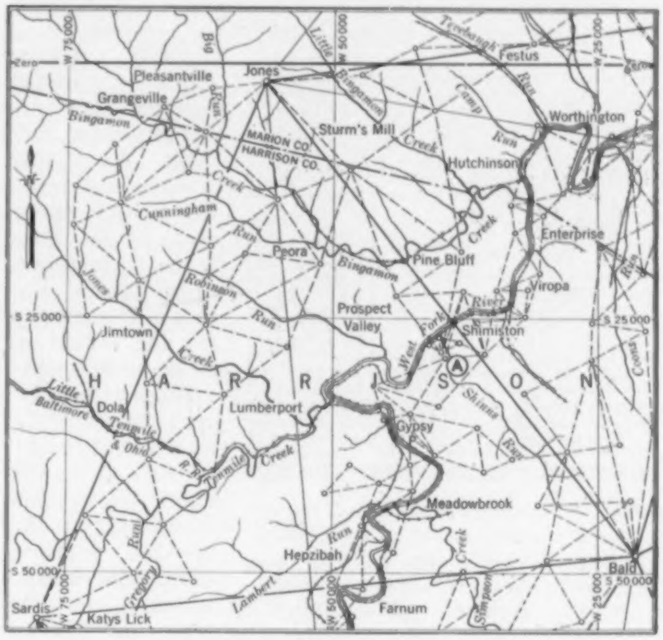


FIG. 2. A PART OF THE FAIRMONT COAL REGION, SHOWING NETWORK OF LOCAL TRIANGULATION SURVEY

Some engineers use the carbon-copy method for field notes and file the duplicates. This method guards somewhat against loss, and also makes notes available in the office that might otherwise be in the field.

The routine of a surface survey made for the purpose of locating gas wells is as follows:

The starting station is found and identified. The transit occupies the station, and the vernier is set on the back azimuth. The top motion is unclamped, and the telescope is sighted on an adjacent station and read. If the reading checks with the original, it confirms the identity of the adjacent station and indicates that the three station points have not been disturbed. A sight

TABLE I. FAIRMONT TRIANGULATION TIED TO U. S. GEOLOGICAL SURVEY TRIANGLES

Lines of Sight	U.S.G.S. Azimuth	Fairmont Gisement	Convergence		Check	Distance in Feet		Diff. Feet
			Observed	Calculated		U.S.G.S.	Fairmont	
Mt. Clare to Sardis	322°41′38.09″	322°47′37.68″	+5′59.59″	+ 6′23.12″	−23.53″	49,041.8542	49,031.4078	−10.44
Mt. Clare to Jones	354°43′03.16″	354°49′06.70″	+6′03.54″	+ 6′23.12″	−19.58″	92,401.2744	92,388.1304	−13.14
Mt. Clare to Egypt	91°29′58.25″	91°35′48.72″	+5′50.47″	+ 6′23.12″	−32.65″	45,491.2639	45,481.3785	− 9.89
Mt. Clare to Bald	30°09′27.55″	30°15′34.71″	+6′07.16″	+ 6′23.12″	−15.96″	52,641.2967	56,634.4748	− 6.82
Sardis to Mt. Clare	142°37′38.74″	142°47′37.68″	+9′58.94″	+10′24.00″	−25.06″	....	....	...
Sardis to Jones	21°44′58.89″	21°54′52.67″	+9′53.78″	+10′24.00″	−30.22″	57,088.9753	57,083.6331	− 5.34
Sardis to Bald	83°19′29.24″	83°29′18.98″	+9′49.74″	+10′24.00″	−34.26″	56,544.7446	56,536.7897	− 7.95
Bald to Mt. Clare	210°13′00.61″	210°15′34.71″	+2′34.10″	+ 2′50.97″	−16.87″	....	....	...
Bald to Sardis	263°27′02.21″	263°29′18.98″	+2′16.77″	+ 2′50.97″	−34.20″	....	....	...
Bald to Jones	323°07′24.27″	323°09′52.00″	+2′26.73″	+ 2′50.97″	−24.24″	58,165.9537	58,158.2877	− 7.67
Bald to Egypt	157°53′29.74″	157°56′12.92″	+2′43.18″	+ 2′50.97″	− 7.79″	50,434.3539	50,422.8942	−11.46
Egypt to Bald	337°56′02.38″	337°56′12.92″	+0′10.54″	− 0′11.69″	+22.23″	....	....	...
Egypt to Mt. Clare	271°36′03.45″	271°35′48.72″	−0′14.73″	− 0′11.69″	− 3.04″	....	....	...
Jones to Sardis	201°47′50.06″	201°54′52.67″	+7′02.61″	+ 7′34.13″	−31.52″	....	....	...
Jones to Mt. Clare	174°41′54.41″	174°49′06.70″	+7′12.29″	+ 7′34.13″	−21.84″	....	....	...
Jones to Bald	143°02′42.79″	143°09′52.00″	+7′09.21″	+ 7′34.13″	−24.92″	....	....	...
Jones to Erwin	81°14′05.66″	81°21′23.24″	+7′17.58″	+ 7′34.13″	−16.55″	50,391.8338	50,381.8637	− 9.97
Erwin to Jones	261°20′49.47″	261°21′23.24″	+0′33.77″	+ 0′50.53″	−16.76″	....	....	...
Erwin to Waters	55°56′08.15″	55°56′29.95″	+0′21.80″	+ 0′50.53″	−28.73″	59,029.0521	59,021.5215	− 7.53
Waters to Erwin	236°02′45.62″	235°56′29.95″	−6′15.67″	− 5′46.30″	−29.37″	....	....	...
				Average:	−20.74″	....	....	...
U.S.G.S. Meridian 0°0′	360°00′00.00″	359°59′10.88″	−0′49.12″	− 0′40.52″	− 8.60″	....	....	...

Fairmont zero of coordinates is latitude 39°28′5.07″, longitude 80°09′53.05″.

Distances given in column headed "Fairmont" are not adjusted to sea level nor are they corrected for curvature or spherical excess.

is then taken on the new station and the azimuth read and recorded. The continuous vernier method is used; that is, after setting the vernier on the original back sight, the verniers are not again reset except in case of mishap. The telescope is always sighted direct, not plunged, and the line from zero to 180 deg on the transit plate is always in the meridian. Every other sight will be corrected 180 deg for the correct azimuth, which can always be confirmed by needle reading.

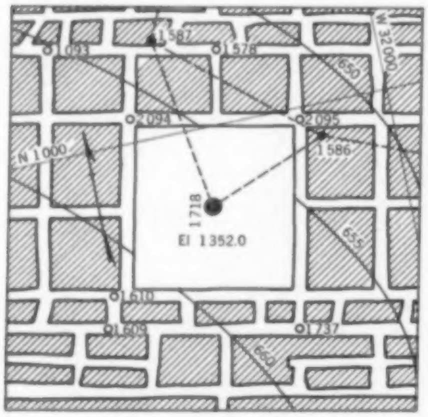


FIG. 3. LOCATION SKETCH OF TYPICAL GAS WELL IN FAIRMONT COAL FIELD

Location of Well Is Plotted from Two Separate Stations of the Surface Survey, Which Is Indicated by Dotted Lines

It has been found very useful to carry elevations in the surface surveys. When this is done, the vertical angles between stations must be read and recorded apart from the measuring angles for the reduction of slope measurements to the horizontal. Here the instrument height of the transit above the station is sighted at the forward station. The angle is designated as "a true angle" to distinguish it from a vertical angle read between stations when the rod of the forward station differs from the transit height. The total horizontal distance is reduced from the measurements of varying length, and slope angles are determined by the topography. The field notes are copied independently into calculation books by two computers. Calculations in one book are made by logarithms and in the other by natural functions, to avoid mistakes incident to the use of identical processes.

After the horizontals and verticals have been computed and checked, the results are entered in the field books and checked. The traverse notes are next copied independently in parallel calculation books designed for the purpose. The calculation notes are entered on traverse sheets, which are then bound into folios.

RESULTS INDICATE ACCURACY OF WORK

It is apparent that whereas the primary meridian is from 8 to 20 sec off the true north, the variation is consistent throughout the entire system. Although the author is not familiar with the U. S. Geological Survey adjustments for the sides of the triangles, it is probable that the measurements of the Fairmont bases are about 1 in 10,000 at variance with the Geological Survey.

The entire system was traversed and tabulated, so that elevations, coordinates, and references were readily available for use in line surveys. Precise levels were run to 20 per cent of the triangulation stations, and the elevations of the remainder were calculated from vertical angles.

The topography of the country was ideal for the survey. The area had been mapped by the Geological Survey, and locations for stations could be selected approximately from the maps. The field work was done by a party of five and was completed in three seasons. Computation required an equal amount of time. Today, the work could probably be done in half the time by utilizing modern means of transportation and calculating devices. Also, the numerous hilltops have been denuded and would require considerably less shifting of position in reconnaissance.

The system afforded a positive base for all transit-line surveys within the area and controlled the distribution of errors in line surveys. Our company established the limit of error at 1 in 5,000, and no difficulty has been experienced in keeping within this limit. All line surveys within the area of a triangle are closed between two stations of that triangle. That is, a line survey is not permitted to pass one triangulation station to close on a more distant one.

The Fairmont base has been adopted by practically all companies operating adjacent properties, so that relative positions of properties are quickly established. The system has been extended very considerably by other companies.

COMMERCIAL ASPECTS OF USING COORDINATE SYSTEM

It is at once apparent that the accuracy demanded by the method discussed is considerably more expensive than that of protractor mapping. Although we used the protractor to fill in minor details, such details were always within mathematical control. Since the coordinate method is more expensive than other methods, its commercial application must depend upon the degree of accuracy required.

When mineral properties were selling at $10 an acre, a survey cost of $10 an acre was out of the question. Increasing values require an increasing degree of survey accuracy. There are, of course, many situations where extreme accuracy is not essential, and in such cases graphic methods suffice and more expensive methods are not justified.

Oil companies, highway departments, railroads, and many other concerns often do not require a fine mathematical determination of points and limits. However, a mining company, operating underground miles from surface outlets, must know at all times the exact position of all points in the mine in relation to all other points therein, as well as to points in an adjacent mine. Positions must also be known accurately with relation to surface features overhead.

For example, in one part of the Fairmont coal field, a large number of gas wells have been drilled through the mineral vein now being operated. These wells are producing as much as 100,000 cu ft of explosive gas daily, and develop rock pressures as high as 750 lb per sq in. Uncertainty under such circumstances would jeopardize life and property values to a degree far beyond comparison with the cost of the necessary surveys.

CONCLUSION

In addition to its advantages in tying in local surveys, the coordinate system makes it possible to reestablish the position of any previously located point which may have been obliterated by change of surface features. As time progresses, populations increase and the earth's surface is altered by the elements and the works of man. Without means of reestablishing positions of property lines, gas and oil wells, mine workings, and other features, their locations would be lost or uncertain (Fig. 3).

The author is of the opinion that the use of coordinates should be more generally followed in fields other than mining, such as city surveys. All intersections of lot or property lines would thus have definite mathematical values, which would facilitate their being located accurately and immediately, and avoid endless duplication of engineering work.

Economics of Highway Planning

Effects of Road Construction on Adjacent Areas and on Taxable Values

ALTHOUGH the far-reaching benefits of highway construction to communities as a whole cannot be questioned, adjacent properties frequently depreciate in value, particularly if they are residential. Moreover, it appears that increases in real estate valuations alone will not begin to pay the cost of building new highways. Care in planning is clearly called for in this situation. The articles which follow are abstracted from two of the addresses delivered on October 15, 1936, before a session arranged by the City Planning Division and the Pittsburgh Section as a part of the Society's Pittsburgh Meeting.

In the first paper, Mr. Arthur's observation of conditions in the Pittsburgh area leads him to believe that properties adjacent to new major highways generally depreciate, that the hinterlands are usually benefited, that districts at the termini always appreciate, and finally that the use of wide rights of way with local-service side roads behind planted screens would go far toward increasing instead of decreasing frontage values. After making a detailed study of Allegheny County as a whole, together with five component rural districts and two suburban areas, Mr. White concludes that if a lag of about ten years is allowed, highway expenditures are reflected to a limited extent in increases in real estate valuations.

Effect of Major Highways on Their Districts

By U. N. Arthur

Member American Society of Civil Engineers
Formerly Chief Engineer, Department of City Planning, Pittsburgh, Pa.

In the report of the Committee of the City Planning Division on the Street Thoroughfares Manual, published as Paper No. 1915 in Transactions, Vol. 100, 1935, it was proposed that a "major highway" be defined as "a highway forming an essential part of a highway system for a region, such as a state, and the right of way of which is not less than 100 ft wide." Engineering planners will generally approve this definition as far as it applies to those cities and regional districts where the topography and physical developments are such as will permit such construction within economic bounds.

However, in those districts having such rugged topography as is found generally throughout the southwestern part of Pennsylvania, and particularly in the Pittsburgh district, the term "major highway" must be restricted so as to include highways having a width of 60, 70, or at most 80 ft, improved with three or four traffic lanes of about 10 ft each. Such restriction is necessary to make the term conform with usage in this district.

Rugged Terrain Hampers Highway Construction
A 120-Ft Cut on the New Lincoln Highway Adjacent to the George Westinghouse Bridge

There are no existing highways either in the city or in Allegheny County that fully comply with the Division's definition, especially in view of its additional qualification that highways carrying traffic in both directions be physically separated by planting or otherwise. On the other hand a by-pass for the William Penn and Lincoln highways has been planned which will fully comply with the requirements of the definition. Some of the right of way has already been secured for this by-pass, which will extend from a connection with the present routes east of Wilkinsburg to the westerly line of Crafton Borough (Fig 1), a distance of 16.3 miles.

During the past twenty years the construction of major highways in Pittsburgh has been planned to keep abreast with the ever-increasing number and speed of motor vehicles. This objective has been extremely difficult to attain, however, for the following reasons:

1. The area within the corporation lines was substantially all laid out in subdivision plans between 1816, when the city was incorporated, and 1910. As a result, the streets are 40, 50, or (rarely) 60 ft wide, and are lined with building lots having an average depth of 100 ft.

2. The rugged topography of the district causes differences in elevation of 20 to 30 ft or more between the fronts and rears of lots. The same grades continue across the streets.

Under such conditions it was financially impossible to construct major highways of the cross-section required to meet present-day traffic demands adequately. Widening narrow streets and opening new streets of the desired width meant confiscating the entire frontage on one side of the street, and often serious damage to the other too. These conditions often gave rise to narrow highways subject on one or both sides to ribbon development of questionable economic importance but causing a decided reduction in traffic capacity. This condition could not have been prevented, as the Pennsylvania laws do not authorize the condemnation of private property for freeways, nor do they permit any restriction of the use of

property abutting on major highways by the owners, except such slight control as may be exercised by zoning ordinances.

HIGHWAY EFFECTS ARE VARIED

In considering the effect of a major highway on the urban district it traverses, attention should be directed to the character of the properties along the new frontage, the hinterland and its accessibility to the highway, the districts at the termini that are served but not traversed, and the standard of construction.

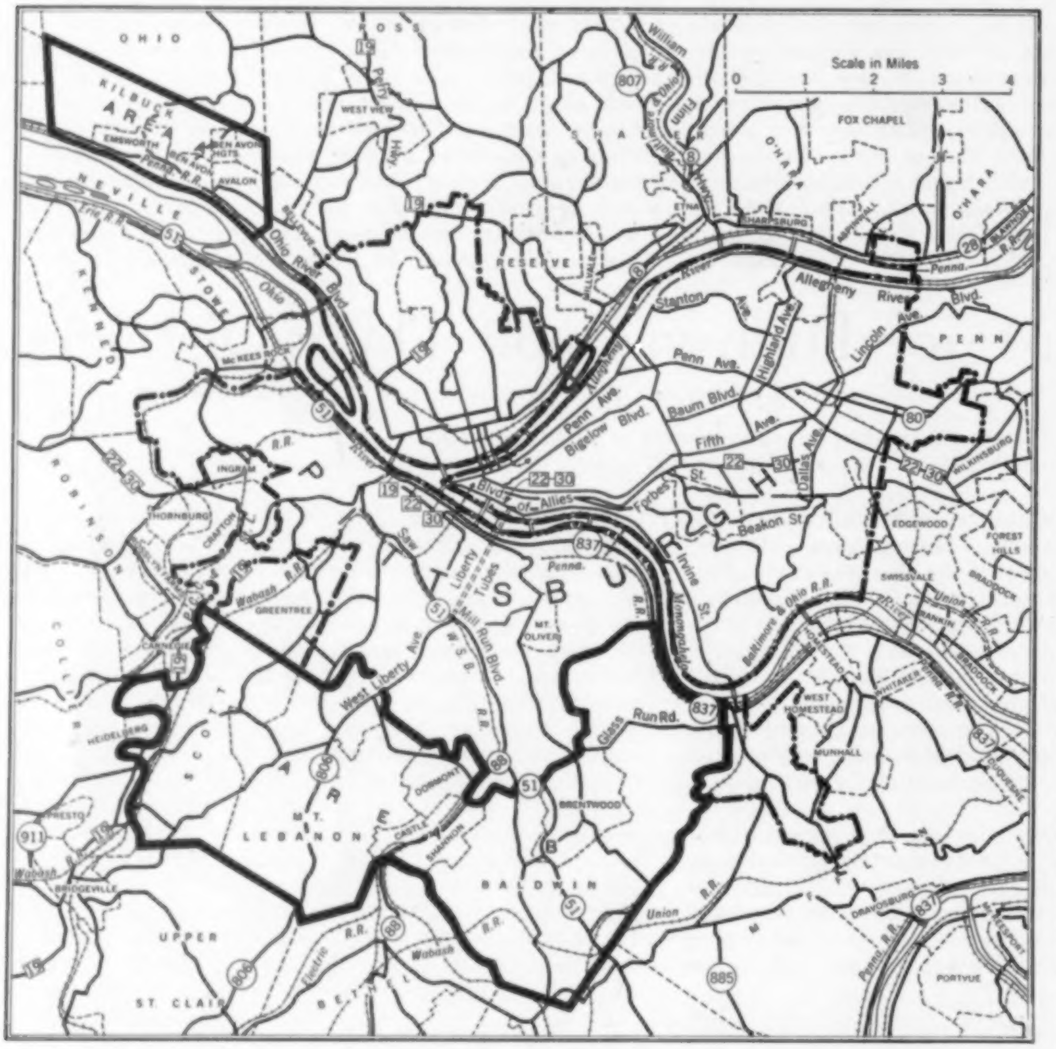


FIG. 1. MAP OF PITTSBURGH, PA., AND VICINITY, SHOWING PRINCIPAL HIGHWAYS
Areas Marked *A* and *B* Refer to Accompanying Article by Joseph White, M. Am. Soc. C.E.

In urban districts, new or widened thoroughfares are usually constructed through the older residential or quasi-business sections. They are designed for the most part to serve the main business districts without disturbing their daily routine. The use of the new frontage, whether by choice or regulation, will reflect the value of any benefits. Frontage on a major street in an established residential district will rarely be improved unless the dwellings are located at least 100 ft back from the property line and at a reasonable elevation above or below the grade of the highway. However, such conditions are not usual in this district. Ordinarily the noise and dust become unbearable, with the result that the frontage depreciates in value and becomes either a blighted residential area or, if not prohibited by the zoning ordinance, a partially occupied commercial or industrial district. In either case the frontage becomes equally unproductive and unattractive.

Better-class residential properties are extremely sensitive to such changes. The slightest breakdown in accustomed conditions, whether caused by increased traffic or by the establishment of a minor commercial use, will effect an immediate decrease in the demand for and a depreciation in the value of these properties, although the result may not be reflected in the assessed values for a considerable period. An illustration of this tendency may be cited. The City Planning Commission had a survey made and plans prepared for widening one of the most highly developed residential streets, increasing it from a 60-ft to an 80-ft street. The properties fronting on the street had previously been selling as high as $500 a front foot. Although no legal action had as yet been taken to authorize the widening, the demand suddenly ceased. It developed that prospective purchasers feared the street would become a speedway, that the front yards would be decreased by 20 ft, and that the shade trees and shrubbery would be destroyed, notwithstanding the consensus of opinion that the widening of the street would materially benefit the community. In general, residential property values in Pittsburgh hold up much better on minor streets.

Districts in the rear of the frontage, on each side of the major highway, benefit from the improvement only if it is properly laid out, is zoned in accord with the general character of the district, and is easily accessible by way of lateral streets having suitable alignment and grade. The highway will afford the essential connection with the various centers of the community and region, thereby increasing their desirability. Accessibility, however, is only one of the factors that govern land values.

Districts at the termini of new thoroughfares in the urban sections receive the greatest enhancement in land values. When they are undeveloped, modern planning gives the district a decided advantage over older and partially developed sections. The construction of a direct outlet from the central business district to South Hills had a very definite bearing on the value and development of the suburban property in the borough of Dormont and the township of Mt. Lebanon. In 1915,

before West Liberty Avenue was widened and improved, the assessed value of Dormont Borough was $4,096,770, and of Mt. Lebanon Township $3,526,730, while in 1924, after improvement of West Liberty Avenue and opening of the Liberty tubes, the valuation had increased to $10,503,450 for the borough and $7,609,950 for the township. By 1929, when the route to the business district had been completed by way of the Liberty Bridge, these valuations had increased to $15,968,400 and $19,983,350, respectively. The worth-while character of these developments is attested by the fact that the assessed valuations continued to increase during the depression. In 1935, Dormont Borough was assessed at $17,163,679, and Mt. Lebanon Township at $28,761,679. Without the highway this section would not have had this remarkable development.

MAJOR HIGHWAYS BENEFIT COMMUNITIES RATHER THAN ADJACENT FRONTAGES

Vast expenditures have been made by the city, county, and state in constructing major traffic routes leading from the central business district to outlying county districts, with connections to important state and national highways, during the past twenty years (although Bigelow Boulevard, the first of these, was built in 1902). Among these highways may be mentioned the Boulevard of the Allies, the Liberty Bridge and tubes, Saw Mill Run Boulevard (incomplete), the Ohio River Boulevard, and the Allegheny River Boulevard, with their connections. These routes have all met the expectations for service and are carrying heavy traffic. They are all three-lane or four-lane highways, and are constructed for the most part in narrow ravines, along steep hillsides, or along the edges of bluffs.

The immediate districts through which they pass are so cramped that little or no resulting increment in land values has resulted, and the opening of these routes has therefore not benefited the abutting properties. On the contrary, depreciation has followed in some cases. For example, the widening of the former Second Avenue, now the Boulevard of the Allies, from a 40-ft to an 80-ft street resulted in a depreciation of the frontage and also of the intervening property between the boulevard and the Monongahela River from Grant Street to Liberty Avenue. This is attributed to the shallow depth of the lots remaining after the widening; to the absence of a lane for the service of the properties, depriving them of essential access (unless they extended through to First or Third avenues); and to the hesitancy of shoppers in crossing a busy six-lane street. Pittsburgh shoppers have become accustomed to crossing a maximum width of roadway of about 36 ft, and are not easily persuaded to venture across one of greater width carrying traffic moving fast in both directions. The opening of this highway has, however, resulted in a decided improvement in property values in the lower Penn Avenue commercial district and the Squirrel Hill residential district.

It is to be regretted that a substantial increase in property values cannot be reported, such as followed the construction of major highways in Chicago, St. Louis, New York, Westchester County, N. Y., and other places with less precipitous grades. Pittsburgh must be content with having the benefits spread over the entire community and not concentrated at any single point. Certainly those larger hinterland districts which have convenient access to the new highways are generally benefited by the greater ease and time saved in reaching other parts of the region and, in residential districts, by the reduction in the volume of fast-moving traffic and in the number of trucks on local streets.

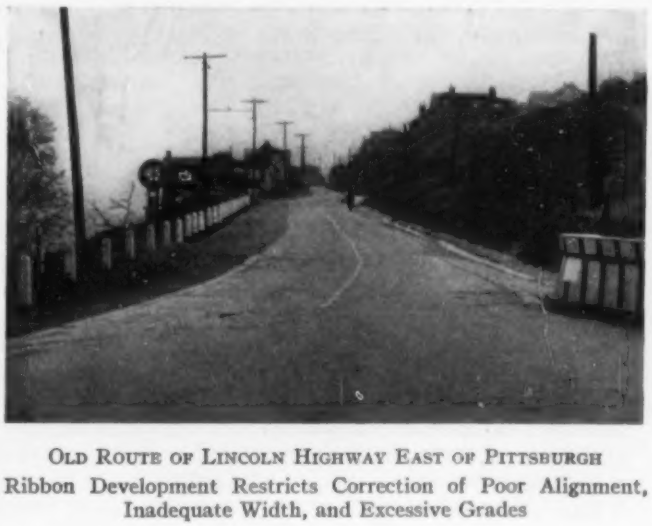
In rural areas traversed by the principal county and state routes, such as the Perry, Lincoln, William Penn, and William Flinn highways, we find another instance of community benefit rather than any specific benefit to the frontage. Following the opening of a modern highway, property fronting on it often experiences an immediate demand at higher land values. But this usually continues for a short period only. The usual purchasers are persons moving out into the open spaces to avoid the congestion and confusion of the city. As soon as they discover that they are not experiencing the desired comfort and quiet, they are inclined to dispose of their holdings at the first opportunity and to relocate on property accessible to, but some distance removed from, the highway.

It is self-evident that the entire length of a major highway system, both urban and rural, cannot be economically developed for commercial or industrial uses. In the Pittsburgh Metropolitan District the frontage is not attractive, for the most part, for residential development desirable for an important traffic route.

During recent years the continual yearly increase in the output of motor vehicles has taxed street and highway capacities. Under the urge of traffic specialists, almost the entire right of way has been converted into roadway at the expense of sidewalk and planting strips. This has had a disastrous effect on property values. In many instances, topography permitting, the picture could be changed if a wider right of way were taken and local service roads constructed with a properly planted screen separating the main traffic lanes from the service roads. This type of construction would add somewhat to the initial cost but would change the frontage from unprofitable land to desirable property, and at the same time add to the safety and comfort of the motorist.

IMPROVED HIGHWAYS AID DECENTRALIZATION

It is not my purpose to present a pessimistic view, or to minimize in any way the importance of major highways, but rather to call attention to certain facts in the hope that the true picture may be more clearly seen and some of the faults corrected. From Revolutionary days to the present, the entire country has been hampered by the lack of ample highways, suitably constructed and maintained. The development of new and varied means of transportation has called for readjustments in the character and design of the highway system. The construction of suitable roads has always lagged behind the demand, and no doubt will continue to do so for



Old Route of Lincoln Highway East of Pittsburgh
Ribbon Development Restricts Correction of Poor Alignment, Inadequate Width, and Excessive Grades

many years. Particularly in the great metropolitan districts, the social and economic well-being of the citizens depends largely upon the facility with which they can travel safely and economically.

The perfecting of motor cars and the modernization of highways have made possible the development of the most remote communities, so that an entire county or region becomes one vast unit. Centers of population are gradually losing the advantage they once had when transportation facilities were limited and it was necessary to locate large industrial and mercantile establishments on railroads close to densely populated districts.

FITTING THE ROAD TO TOPOGRAPHY IS OFTEN UNSATISFACTORY
This Part of the Old Lincoln Highway East of Pittsburgh Illustrates Very Poor Alignment

There is a growing movement toward the establishment of business and industrial plants in rural sections where large land areas may be secured at substantial savings. The tendency shown by the well-to-do citizens to move out several miles into rural districts and there establish communities of large estates is also a growing source of property depreciation in cities. These trends, directly attributable to ease in traveling comparatively long distances, are undoubtedly contributing to the breakdown of the older residential areas within our cities and the creation of slum districts.

The urge to decentralize and spread over large areas is equivalent to increasing a city area from 30, 40, or 50 sq miles to 900 or 1,000 sq miles without any corresponding increase in the population of the district involved. Regardless of the decentralizing movement and the multiplication of new political subdivisions, there is a constant demand for costly improvements and better maintenance of all public-works structures within the city proper. This condition, in the face of a reduction in revenue, is evidently one of the problems for the engineer-planner and the public-works engineer to solve. Regional planning may be the answer. But in order to effect the essential economies and to render the service demanded, there must be a drastic change in the set-up of the regional political subdivisions, providing for the unification of construction activities and directional and taxing powers under a single authority.

A keener appreciation of the problems created by high-speed traffic arteries in the central districts of cities, together with the development of coordinated plans for major highways between business districts and residential centers, may tend to lessen the strain and render the former a service rather than to promote decadence.

SAFETY AND PERMANENCY ARE IMPORTANT

A few years ago a two-lane roadway designed for speeds of from 35 to 40 miles an hour fully met the demand. The vast sums spent on these roads were largely wasted, as in a very short time the new motor-car models, built to maintain much greater speeds, called for improved designs and extensive reconstruction. No doubt the failure of much of our early construction was due to the attempted conversion of old wagon trails into adequate motor routes with only minor revisions.

The design of major highways has not kept pace with advances in the design of automobiles. As engineers it is our duty to modernize our methods of location, design, and construction so that the highways we build will meet the demands of the future as well as the present. The argument that we are unable to anticipate future needs is no longer valid, as it is unlikely that modern designs founded upon comprehensive surveys and experience will become obsolete. The new major highways must be built for safety and permanence.

In mountainous sections, locations of major highways with satisfactory alignments and grades can only be established after extensive topographical surveys have been made to develop all practicable locations and to determine the relative advantages of routes and costs of rights of way and construction. Surveys are much cheaper than construction and should be fully developed. In every case the full right of way should be secured, and the damages and benefits arising from the appropriation of property should be finally adjudicated before any construction work is started.

In conclusion, may I point out that the engineer is by training and experience better qualified to assume the rôle of planner in locating major highway systems, than the professional planner who has not had experience in surveying, estimating, and construction.

Highway Cost Related to Taxable Values

By JOSEPH WHITE
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TRAFFIC ENGINEER, ALLEGHENY COUNTY DEPARTMENT OF WORKS, PITTSBURGH, PA.

TO what extent have real estate valuations in Allegheny County, Pa., responded to the highway expenditures made during the past forty years? The generally accepted theory that improved highways promptly increase the valuations of real estate sufficiently so that enough tax funds are provided to defray the cost of the improvements can readily be proved to be in error. If real estate valuations had increased sufficiently during the past twenty years to pay for the highways, there would have been no necessity to increase the road tax millage from 50 cents for $1,000 valuation in 1920 to $3.37 (including proportion of debt millage chargeable to outstanding highway bonds) in 1930.

To clarify this issue it must be understood at the outset that modern highways have two effects. First, they undoubtedly increase real estate valuations to some ex-

tent over a period of time. Second, they provide service and create, rather promptly, additional wealth by reducing the cost of distribution by such means as saving time in getting from one place to another, reducing the cost of machine repairs, increasing the mileage per gallon of gasoline, bringing the farmer closer to his market, and expanding the business area of the merchant.

In Pennsylvania the Flinn Legislative Act of 1895 gave the boards of county commissioners the right to levy taxes for the purpose of building and improving county highways. Previously, the road system of Allegheny County consisted of local streets, township roads, and privately owned turnpikes on which tolls were exacted. Since 1895, the boundaries and area of the county have not been changed, so that no changes in valuation are attributable to that factor. Table I shows the changes that have taken place in the assessed real estate valuations of the entire county over a period of 45 years at five-year intervals and includes also figures for 1935. The population is given for each census year as well as the rates of increase in population and valuation in each ten-year period.

With the exception of a very sharp rise between 1905 and 1910 and an evident flattening between 1930 and 1935, the rate of increase in valuation has been reasonably constant. The absence of apparent relationship between rates of increase in valuation and population is rather surprising, because of the generally accepted theory that population fundamentally affects valuation. Doubtless with more exhaustive research this apparent contradiction could be reconciled, but the effect of population on valuations is too exhaustive a subject to include in this study.

ALLEGHENY COUNTY'S HIGHWAY SYSTEM

At present the highway system of Allegheny County consists of about 400 miles of improved state highways, 460 miles of improved state rural routes, 500 miles of improved county highways, and many hundred miles of township roads, in addition to improved streets within cities, boroughs, and townships. The area of the county is 745 sq miles. Because of the rugged topography, modern highways are very expensive, and costly bridges are required over the many rivers and ravines. In fact, Allegheny County has more bridges per square mile than any other region in the world.

Since 1895 the county has been investing large sums in its highway system. In each succeeding decade since that year the amount of money invested in highways has increased. This money has been invested not only to build new roads but also to improve the existing mileage. Practically every mile built between 1900 and 1910 has had to be widened, reconstructed, or modernized to meet present traffic requirements.

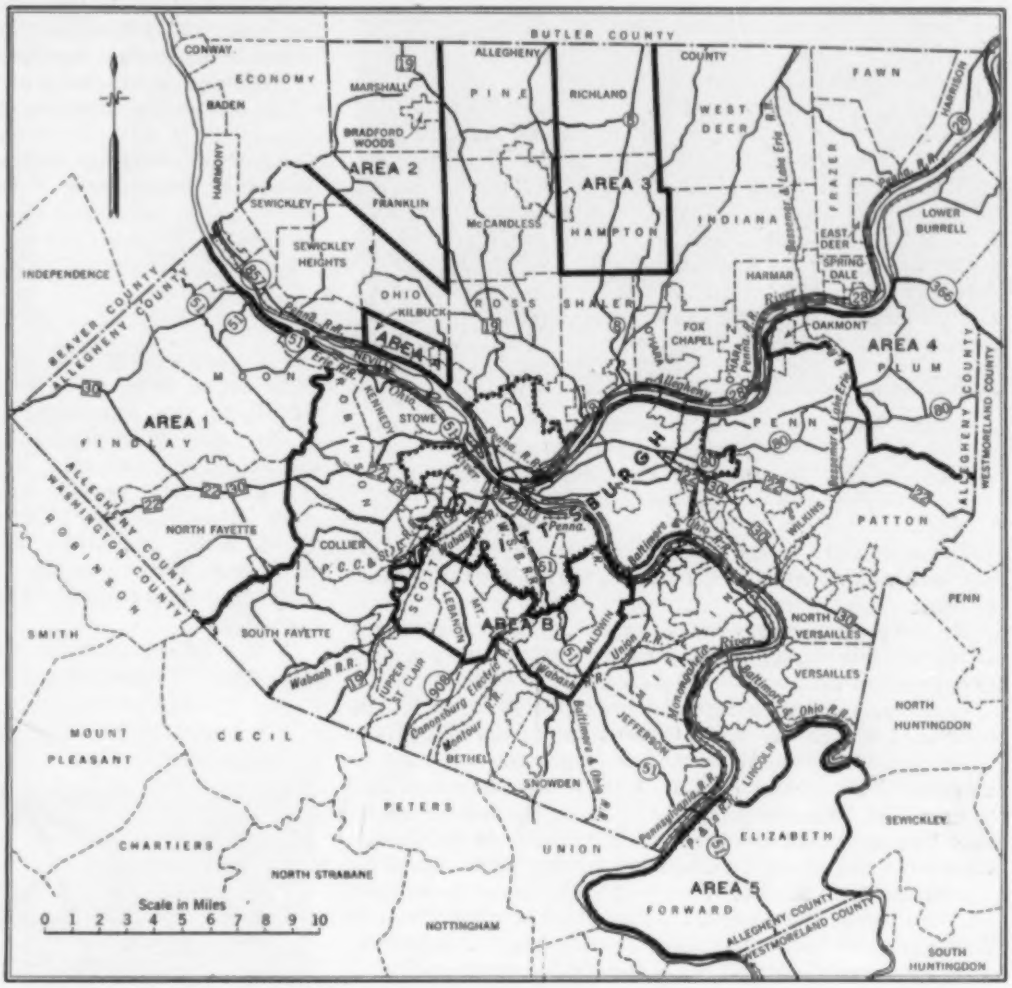


Fig. 1. Map of Allegheny County, Pa., Showing Principal Municipal Subdivisions and Highways

For Large-Scale Map of Central Areas See Accompanying Article by U. N. Arthur

In Table II, the approximate amounts spent by the county in each 10-year period from 1890 to 1930, inclusive, are compared with the corresponding rates of increase in assessed real estate valuations. These amounts do not include either expenditures for bridges and tunnels or the money invested by the state on highways within the county. It will be first noted that real estate valuations do not apparently respond, decade by decade, to the highway expenditures during the period shown,

Table I. Comparison of Valuations and Population, Allegheny County, 1890 to 1935

Year	Valuation	Population	% Increase Valuation	% Increase Population
1890	254,716,562	551,959	..	..
1895	432,549,830	......	..	..
1900	482,875,320	775,058	90	40
1905	576,175,102	......	..	..
1910	1,031,739,440	1,018,463	114	31
1915	1,144,467,310	......	..	..
1920	1,277,245,130	1,185,808	24	16
1925	1,562,178,235	......	..	..
1930	1,780,830,230	1,374,410	39	16
1935	1,801,003,256	......	..	..

but in making a further analysis of these figures the following considerations must be given consideration:

1. Numerous factors besides highways influence real estate valuations, such as industrial developments; railroad-service and street-car extensions; initiative and progressiveness on the part of the residents within the various districts of the county; the enterprise of building-and-loan associations, realtors, and financial institutions.

LIBERTY BRIDGE OVER THE MONONGAHELA RIVER, LOOKING TOWARD PITTSBURGH'S TRIANGLE

This Structure, Together with the Liberty Tunnel, Helped Increase Valuations in Areas South of the City

2. As automobiles were not generally used until about 1910, the advantage of good roads was not pronounced previous to that date.

3. It is natural to expect a lag or delay between the date that a highway improvement is completed and the time that it registers itself on real estate assessments.

From these considerations it may be concluded that the striking increase of 114 per cent in assessed real estate valuations in the period 1900–1910 cannot be attributed to highway expenditures to any great extent.

To allow for the time required for the improvements to be reflected in the assessed valuation, the data given in Table II have been rearranged to compare the valuation increase in each decade with the highway expenditures of the previous decade, as follows:

Highway expenditures	1900–1910	$13,000,000
Percentage increase in valuation	1910–1920	24 per cent
Highway expenditures	1910–1920	$25,000,000
Percentage increase in valuation	1920–1930	39 per cent
Highway expenditures	1920–1930	$57,000,000
Percentage increase in valuation	1930–1940	Unknown

This arrangement indicates that there is a relationship between expenditures and valuation increases, but as a period of only two decades is covered, it is not broadly conclusive. It will be interesting to see to what extent the expenditure of $57,000,000 in 1920–1930 will affect future valuations. Unfortunately the depression will introduce a disturbing influence. For the five-year period from 1930 to 1935, the increase in valuation has amounted to only about 1 per cent.

STUDY MADE OF FIVE AREAS WITHIN THE COUNTY

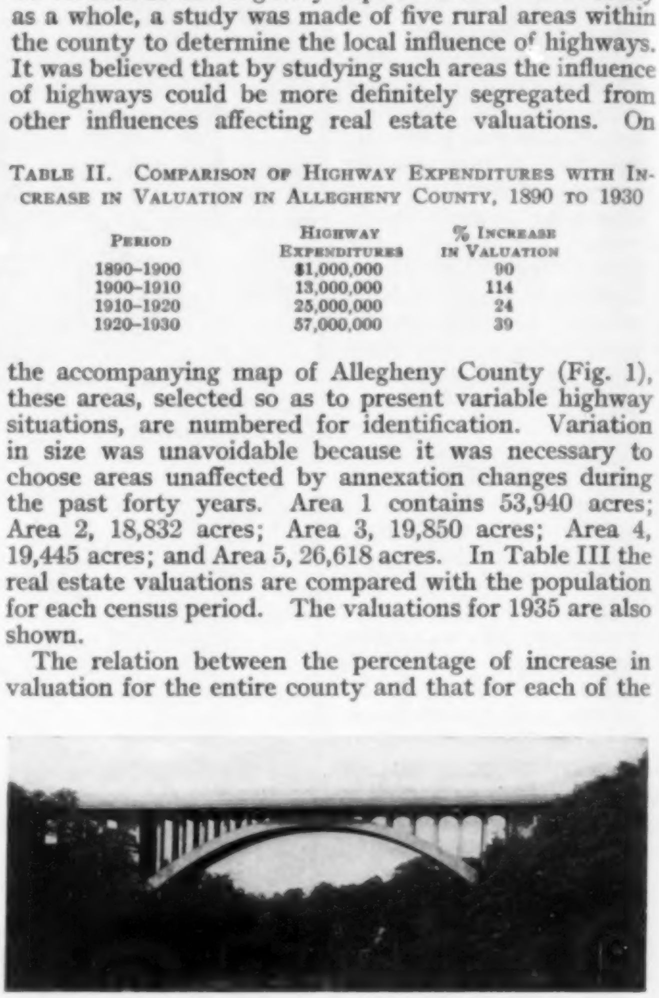
In addition to the computation of comparative figures on valuations and highway expenditures for the county as a whole, a study was made of five rural areas within the county to determine the local influence of highways. It was believed that by studying such areas the influence of highways could be more definitely segregated from other influences affecting real estate valuations. On

TABLE II. COMPARISON OF HIGHWAY EXPENDITURES WITH INCREASE IN VALUATION IN ALLEGHENY COUNTY, 1890 TO 1930

PERIOD	HIGHWAY EXPENDITURES	% INCREASE IN VALUATION
1890–1900	$1,000,000	90
1900–1910	13,000,000	114
1910–1920	25,000,000	24
1920–1930	57,000,000	39

the accompanying map of Allegheny County (Fig. 1), these areas, selected so as to present variable highway situations, are numbered for identification. Variation in size was unavoidable because it was necessary to choose areas unaffected by annexation changes during the past forty years. Area 1 contains 53,940 acres; Area 2, 18,832 acres; Area 3, 19,850 acres; Area 4, 19,445 acres; and Area 5, 26,618 acres. In Table III the real estate valuations are compared with the population for each census period. The valuations for 1935 are also shown.

The relation between the percentage of increase in valuation for the entire county and that for each of the five areas studied is plotted in Fig. 2. It would prove instructive to determine similar trend lines for sub-areas which would cover the entire county, so as to study the effect of shifting valuations.



THE CONCRETE ARCH AT JACK'S RUN IN THE CITY OF PITTSBURGH HAS A 320-FT. SPAN

A Typical Structure in Rugged Allegheny County, Which Has More Bridges per Square Mile Than Any Other Region in the World

It is to be noted that in the first two decades (1890 to 1910) Areas 2 and 3 depart noticeably from the county trend and from the trend of the other three areas. This may be due in part to the fact that there are no secon-

TABLE III. VALUATION AND POPULATION OF FIVE RURAL AREAS IN ALLEGHENY COUNTY

PERIOD	AREA 1				AREA 2				AREA 3				AREA 4				AREA 5			
	Valuation		Population		Valuation		Population		Valuation		Population		Valuation		Population		Valuation		Population	
	Am't	% Increase	Am't	% Increase	Am't	% Increase	Am't	% Increase	Am't	% Increase	Am't	% Increase	Am't	% Increase	Am't	% Increase	Am't	% Increase	Am't	% Increase
1890	3,318,100	..	7,595	..	747,945	..	1,681	..	1,222,564	..	2,139	..	1,758,335	..	3,360	..	3,089,120	..	9,431	..
1900	5,234,231	58	10,912	44	821,910	10	1,525	10*	1,480,090	21	2,459	15	3,061,621	74	4,465	33	3,403,765	10	10,967	16
1910	10,246,500	96	14,829	36	1,203,810	46	1,547	1	1,941,720	31	2,876	17	6,595,410	112	5,785	30	6,821,000	100	14,205	29
1920	15,628,820	52	17,379	17	1,724,940	43	2,100	36	3,383,880	74	3,081	7	10,086,950	53	8,367	50	8,411,690	23	14,198	0
1930	22,649,820	45	22,719	31	2,186,600	27	2,666	27	6,098,290	80	5,138	67	12,785,020	27	12,366	48	9,153,430	9	14,044	1*
1935	22,785,194	..	....	..	2,356,086	..	...	..	6,493,478	..	...	..	13,008,720	..	....	..	8,943,084	..	....	..

* Indicates percentage decrease in population.

ary business centers closely adjacent to these two areas, as is the case with the other three areas. Two distinct influences undoubtedly affect the valuation of rural areas, accessibility to Pittsburgh and accessibility to secondary business centers.

In the areas under consideration there is little apparent relationship between the rates of increase in valuation and the rates of increase in population for corresponding decades (Table III). This was to be expected, as a similar condition was evident for the county as a whole.

The approximate expenditures for highways made by the county in the five areas during the three decades 1900–1930 include the amounts spent for new road construction and reconstruction. They do not include the expenditures for road maintenance, those made by the state, or those made by either the country or the state for highways outside the areas which might have affected valuations within the areas.

In Table IV, these highway expenditures are compared with valuation increases for a 20-year period, allowing a lag of 10 years between expenditures and valuations.

Table IV. Comparison of Highway Expenditures with Increases in Valuation in Five Areas in Allegheny County

Area	Highway Expenditures 1900–1920	% Increase in Valuation 1910–1930
No. 1	$1,357,100	121
No. 2	254,500	82
No. 3	615,900	214
No. 4	709,400	94
No. 5	1,110,100	34
Average of areas	809,000	109

It will be noted that there is a semblance of a relationship between expenditures and valuations in Areas 1, 2, and 4, while the chief divergence is in Areas 3 and 5. In several of the studies, these two areas showed a lack of conformity with the other three. It is to be noted that Area 3 disturbs the sequence by showing an excessively high percentage of increase in valuation for low expenditures while Area 5 shows the reverse—an extremely low percentage of increase for high expenditures. This is very informative, as will be shown later. The percentage of increase in valuation for the entire county during 1910–1930 was 73 per cent. It is to be noted that all areas except No. 5 exceeded the county average.

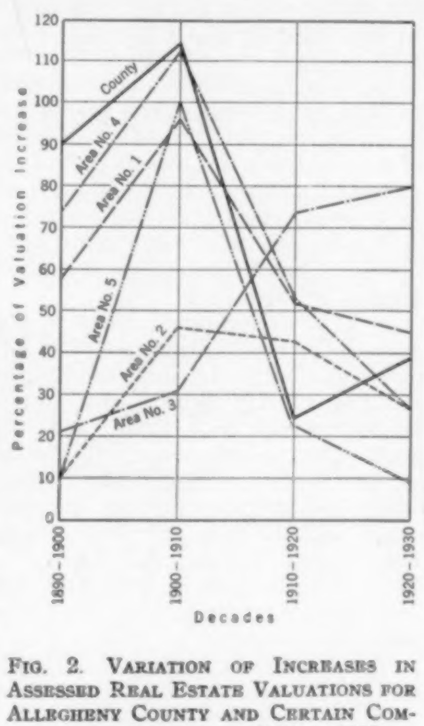


Fig. 2. Variation of Increases in Assessed Real Estate Valuations for Allegheny County and Certain Component Areas from 1890 to 1930

In analyzing valuation changes due to highways, two classifications of improvement must be considered: (1) Through highways within and beyond the area which bring it closer to Pittsburgh; and (2) local highways within the area which affect general development and bring the area into more effective communication with secondary business centers.

It is not feasible to allocate to a particular area the right proportion of the expenditures made in through highways serving the area, so that the extent of service of through highways to these five areas must be generalized.

This Is Not a European Bridge but the Former Span Over the Allegheny River at Sixth Street, Pittsburgh
Designed by Roebling and Erected in 1860; Abandoned in 1892

Until 1920, Area 3 had the most adequate through-highway service to Pittsburgh. This premier position with relation to through highways permitted that area, with moderate expenditures for local highways, to attain the highest increased valuation. Until 1920, Area 5 doubtless had the least adequate through-highway service to Pittsburgh. Although this area was benefited by almost the highest expenditures for local roads, it showed the lowest increased valuation. Until 1920, Area 2, with fair through-highway service to Pittsburgh, had least expenditures for local highways. With the exception of Area 5 it showed the smallest increase in valuation. The 82 per cent increase is due in part to an immediate response to highways built within the area between 1925 and 1930.

This study shows rather conclusively that both types of highway service are needed for the development of rural areas. Through highways unsupported by an adequate system of local roads are not effective. Moreover, expenditures for local roads, without adequate through highways, will not develop an area to the fullest.

Two Urban Areas Also Studied

In addition to the five outlying rural areas, two areas of an urban nature closer to Pittsburgh were studied. These are designated as Area A and Area B in Fig. 1. Area A contains 2,778 acres and in 1930 its population was 12,957. It practically adjoins Pittsburgh and represents an overflow suburban development. At an early period it had good railroad and street railway service, so that it naturally was not as dependent on county highways as the more remote rural areas. Area B contains 15,758 acres with a population of 48,358 in 1930, and has a population density of 3.06 per acre compared with 4.66 in Area A. The average density of population of the five rural areas previously discussed was 2.43 per acre. Area B is slightly closer to Pittsburgh by air-line distance than Area A, but before the tunnels penetrated Mt. Washington it was much farther away in travel time.

In Table V are shown the assessed real estate valuations of Areas A and B over a period of 40 years at 5-year intervals, with the population census at 10-year intervals. The percentage of increase in both valuation and popula-

tion at 10-year intervals is also shown. The absence of relationship between valuation and population which was noted in the cases of the entire county and the five rural areas also prevails in these two urban districts. The high percentage of increase in valuation in these two areas in the 1900–1910 decade is also noteworthy. These

HIGHWAY CONNECTIONS TO PITTSBURGH IN BUSINESS DISTRICT ARE INCREASING
The Sixth, Seventh, and Ninth Street Bridges Over the Allegheny Are Identical Self-Anchored Suspension Spans

increases cannot be attributed to county highway expenditures, since they occurred before the auto age.

The unusual increase in valuation of 185 per cent in Area B during 1900–1910 was due largely to the electric-railway tunnel completed in 1904. The influence of this tunnel and of the extension of the street railway system continued to be felt from 1910 to 1920, with an additional impetus caused by the county's expenditures on highways. While the increase in valuation in Area B during 1910–1920 was 62 per cent, considerably less than its previous increase of 185 per cent, it showed vigorous growth when compared with the 24 per cent increase within the country as a whole.

In 1920–1930 the Liberty Tunnel and Bridge were completed at a cost of about $9,500,000, with an additional expenditure of about $1,127,000 for highways within the boundaries of this area. The Liberty Tunnel and Bridge are not within the area, but are vital arteries to it. The valuation increase in this decade leaped to 166 per cent as against 62 per cent in the previous one.

TABLE V. ASSESSED REAL ESTATE VALUATION AND POPULATION OF AREAS A AND B

Year	Area A				Area B			
	Valuation	Population	% Increase Val.	% Increase Pop.	Valuation	Population	% Increase Val.	% Increase Pop.
1890	$ *	2,947	..	..	$2,760,980	7,511	..	..
1895	2,528,445	...	..	..	4,513,475	...	..	..
1900	2,874,325	5,152	..	75	4,919,153	12,187	78	62
1905	4,496,285	...	..	..	6,133,460	...	..	..
1910	7,991,320	8,986	179	74	13,796,580	15,082	185	24
1915	8,868,840	...	..	..	17,375,500	...	..	..
1920	9,474,600	9,947	18	11	22,356,940	22,616	62	50
1925	10,836,130	...	..	..	38,758,470	...	..	..
1930	13,011,870	12,957	37	30	59,437,370	48,358	166	114
1935	13,102,151	...	..	..	66,402,033	...	..	..

* Not conveniently available.

This area was favored by special conditions which cannot be applied to other areas. Though close to Pittsburgh it was not convenient to it because of Mount Washington. This barrier on the other hand benefited the section climatically. Tunneling the barricade for motor-vehicle traffic consequently proved a double boon. It is undoubtedly true that valuations in this area responded immediately to the expenditures, because conditions were ripe for the tunnel and bridge and the community had been developing in anticipation of them.

Has increased real estate valuation within Area B, by itself, provided sufficient revenue to date to pay for the $10,000,000 tunnel and bridge investment? In 1920 the county tax millage was $3.25 and the road tax millage $2.00 per thousand dollars of valuation, making a combined tax of $5.25 per thousand. If this tax rate had remained the same, and this should be assumed if the revenue due to increased real estate valuations exclusively were to provide the necessary funds, the computed tax income from this area from 1920 to 1935 would have amounted to $3,928,512.10.

In closing, the following conclusions seem warranted from the investigation:

1. Lack of increase in real estate valuations to meet the cost of highway improvements does not indicate that the highway expenditures were not a paying investment, because highway improvements develop wealth in other ways than by increasing real estate valuations.

2. Rate of increase of real estate valuation did not apparently correspond, decade by decade, to the rate of increase in population, either in the county or in various areas of the county which were investigated separately. More research should be devoted to this subject.

3. The rate of increase of real estate valuations in the entire county did not correspond decade by decade to the highway expenditures. When, however, a ten-year interval was allowed as time for the improvements to register themselves on valuations, there appeared an evident relationship over a span of two decades.

4. In studying the effect of highways on valuations of five outlying rural areas within the county, it became evident that the effect of highways on valuations depends to a great extent upon the balance maintained between the development of local roads within the area and the construction of through highways to the central business district of Pittsburgh.

5. The exceptional growth in population and valuation of the South Hills District (Area B) was primarily influenced by the street-railway tunnel, the Liberty Tunnel, the Liberty Bridge, and numerous other highway improvements, both within and without this area. In spite of its exceptional growth, the computed tax revenue derived from the South Hills District between 1920 and 1935, due exclusively to its increased real estate valuations, will not have provided sufficient funds to pay for the Liberty Bridge and Tunnel. However, territory beyond the boundaries of this district was affected favorably and other advantages besides real estate valuations must be considered.

6. This investigation forcefully emphasizes the necessity of carefully analyzing the economic aspects of proposed highway improvements in order to plan, design, and construct highways and bridges effectively.

Economics of Energy Generation

Steam Versus Hydro; Cost Trends; Economies of Interconnection; Social Problems; Subsidies

SOCIAL and political aspects of power problems are becoming constantly more prominent. On the one side are the proponents of increased government participation in power production and distribution; on the other, the advocates of private initiative. A perhaps more basic controversy divides those who would subsidize certain "uneconomical" markets from those who demand that each extension of service justify itself on a long-term dollars-and-cents basis.

Obviously, a discussion of power economics from the engineer's point of view must today include other than technical factors. Similarly, the development of an intelligent power policy, though it may rest largely in the hands of non-technical men, must be predicated on a clear understanding of engineering trends. Engineers, economists, and social planners should all find interest, therefore, in the present symposium. The original papers were read at the technical sessions sponsored jointly by the Power Division and the Engineering-Economics and Finance Division on October 14, 1936, at the Society's Fall Meeting in Pittsburgh. Because of the possibility that they may be treated more fully in Society publications at a later date, brief summaries only are presented here.

The trend of power costs has long been definitely downward. The technical advances that have made this trend possible are traced in the first three papers. Next, the principal factors in the cost of power are discussed, emphasis being placed on the relative economy of hydro and steam plants. In the concluding papers social questions are taken up: Does increased use of power mean permanent unemployment? Does cheap transmission tend to decentralize industry? What part should government take in subsidy or control?

Energy Generation by Heat Engines

THE TOTAL HORSEPOWER of prime movers in this country has increased more than seventy-fold in the past 40 years, according to Geo. A. Orrok, M. Am. Soc. C.E., consulting engineer (Orrok, Myers, and Shoudy, New York, N.Y.). It is now in excess of 1,230,000,000 hp. Of this amount, more than 90 per cent is credited to transportation, and almost 79 per cent is in automotive engines alone. The average per capita use of power, central station and industrial, is probably about 1,115 kwhr per year. Including power used in transportation, the per capita use may be taken as the equivalent of about 2,300 kwhr. Per capita use is constantly increasing and there is little sign of approaching saturation.

Increase in the thermal efficiency of steam plants has been rapid. In 1882 Edison considered 10 lb of coal per kwhr a good record for the first central station. Today at least one plant is producing the same amount of power regularly with 0.86 lb. The entire steam central station output of the country is generated at an average expenditure of about 1.45 lb of coal per kwhr. Industrial plants require about 3 lb.

Boiler-house efficiencies increase slowly, for the law of heat transfer is fundamental. Progress has been in two directions—learning how to burn all the fuel at the best condition, and adding heat traps to catch all heat not absorbed by the boiler proper. The feedwater heater, the superheater, and the economizer have been reintroduced. Water-cooled furnaces (invented more than 100 years ago) have come into general use. The stoker has been improved and the burning of pulverized coal has been perfected.

Up to 1900, the heat engine was the steam engine of Watt and his successors. Then came the steam turbine, in small sizes at first—then larger and larger. A three-shaft unit of 208,000 kw was installed in 1929. The vacuum and the water rate have been improved; today we strive for an absolute pressure of 1/2 to 5/8 in. Hg, and water rates of around 9 lb per kwhr are common.

The value of high pressure and high superheat is thoroughly recognized; 42 stations carry pressures of 500 lb or more, and in Europe installations using steam at the critical pressure (3,200 lb) are in operation. Since 1922 bleeding has become common; as many as six stages of feedwater heating have been used, and feedwater is heated nearly to the saturation temperature.

Curiously enough, with all these developments, the cost of central stations has varied but little since Edison built the Pearl Street station. The cost of building and electrical equipment has increased, while the cost of machinery has decreased.

Steam central stations are now in operation giving yearly over-all economies as low as 11,000 Btu per kwhr—a thermal efficiency of 31 per cent. By the use of the mercury vapor cycle the economy might be increased to about 9,200 Btu, but the plants would be complicated and costly. A steam plant running at 10,000 Btu, however, is a possibility of the near future.

But are these very efficient plants justified? What is the relation between thermal efficiency and commercial efficiency? A steam plant, unlike a hydro plant, cannot charge off a large part of its cost to irrigation, navigation, or flood control. Even with expensive coal ($5 per ton) fixed charges will run from 36 per cent of the total cost of power at a 100 per cent load factor to 73 per cent of the cost at a 20 per cent load factor. Each plant is a unique problem in which the prime cost of installation must be balanced against hours of use and fuel cost to secure the most favorable combination.

The road to commercial economy of course lies in increasing the hours of use of a given installation. And it is true that load factors have improved. Edison at Pearl Street was pleased with a 12 per cent load factor; today system load factors may reach 40 per cent, and certain industries maintain a load factor of 70 per cent or more. These increases will stimulate the use of higher temperatures and pressures and result in a more general distribution of the benefits attained.

Progress in design and efficiency of internal combustion engines has been steady but not so spectacular. Otto cycle engines using gasoline have always been able to develop a brake horsepower-hour on 0.6 lb of fuel. Aviation engines now give a brake horsepower-hour on 0.4 lb of fuel. Diesel engines do slightly better. Solid-injection two-cycle Diesels are now the standard, and can be made to reach economies of 9,000 Btu per kwhr (for the prime mover alone). This economy is

in the same range as that of the most efficient steam plants, but with internal combustion engines it is easier of attainment. At best there would appear to be about 10 per cent in favor of the internal combustion engine in thermal economy. On the other hand, the installation cost is usually higher than for steam.

What of the future? Some modern scientists and engineers have predicted that our next step will be atomic power. However, Millikan's final summary on this prediction is that power from atomic degradation can never be generated in commercial amounts. In at least two locations we now use steam power generated by the heat of the earth's magma. At Washington, Dr. Abbott recently exhibited his solar engine, three to four times as efficient as previous models.

None of these proposals, concluded Mr. Orrok, meet the criterion of a commercial power plant that must generate power when wanted, as wanted, and at a cost a little less than that of present plants. Engineers, scientists, and inventors are looking for a new source of power, convenient, plentiful, and cheap. But until that source appears it is certain that a major part of our power will be generated in heat engines, using steam as the heat medium.

Hydro-Generation of Energy

PROGRESS IN THE generation of energy by water power was traced by Frank H. Rogers, chief engineer of the I. P. Morris Division of the Baldwin-Southwark Corporation. General trends along a number of lines are illustrated by Fig. 1.

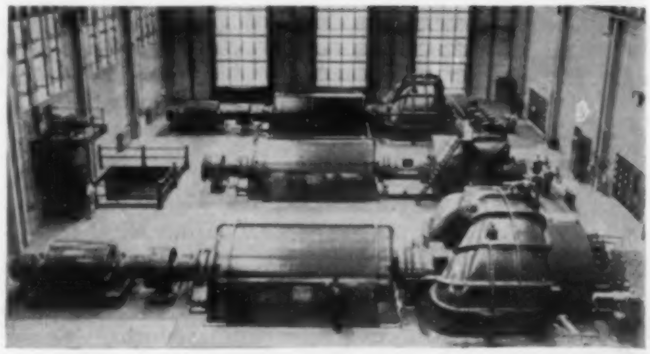
Since about 1910, said Mr. Rogers, most turbine installations have been of the vertical-shaft type. This has permitted the building of very large units. Efficiencies have increased but little since 1920, as the possible limit had been closely approached at that time. The most important development in the recent history of turbine design has been the increase in specific speed made possible by the propeller-type turbine.

Impulse turbines have been built in this country up to 70,000-hp capacity for heads up to about 3,000 ft. In recent years there has been considerable improvement in efficiencies in this type of wheel, which may be credited to research in the design of buckets and nozzles. The straight-flow nozzle is an important innovation.

Reaction (Francis-type) turbines have been used up to heads of about 850 ft. The 115,000-hp units at Boulder Dam, operating under a maximum head of 590 ft, are the most powerful reaction turbines installed to date.

Leakage at the runner seals is important in high-head units; any increase of clearance due to wear materially reduces the efficiency. A very close clearance can be used safely by adopting for the stationary seal an insert of soft metal.

For turbines designed to operate under medium head (100 to 300 ft), the two-bearing unit with umbrella-type generator is an excellent design. Field tests of



THREE COMPACT STEAM TURBINE-GENERATOR UNITS AT PHILO, OHIO; COMBINED CAPACITY 165,000 KW

this type of installation have shown over-all efficiencies from headwater to tailwater of 92.6 per cent.

The propeller-type runner has made it economical to develop large low-head installations, primarily because its high speed permits the use of less expensive generators; it also reduces the cost of the power-house superstructure. There is one inherent weakness of the fixed-blade high-speed propeller—the rapid drop in efficiency at part load. This is overcome in the adjustable-blade (Kaplan) runner, in which the blade angle is automatically varied to suit the load demand. The 66,000-hp units now being built for the Bonneville development are the largest and most powerful units of this type yet constructed in this country. The operating head is 69 ft.

Model research by manufacturers has had an important bearing on recent turbine design. The model units, having runners usually 16 in. in diameter, are exactly homologous to the full-size units, even in such details as intake, casing, and draft tube. Changes in all features can easily be made to obtain the best possible combination before constructing the full-size units, and the performance of the latter can be predicted accurately.

Since the development of the high-speed runner, the question of cavitation has assumed far greater importance than it formerly had. The main problem in this connection is to determine in the laboratory the correct elevation of a given runner with respect to tailwater. Such laboratories are equipped to vary the elevation of the tailwater while the total head remains constant. As the tailwater is lowered, observations are made on the efficiency, output, and discharge, and the break in these curves indicates the cavitation limit.

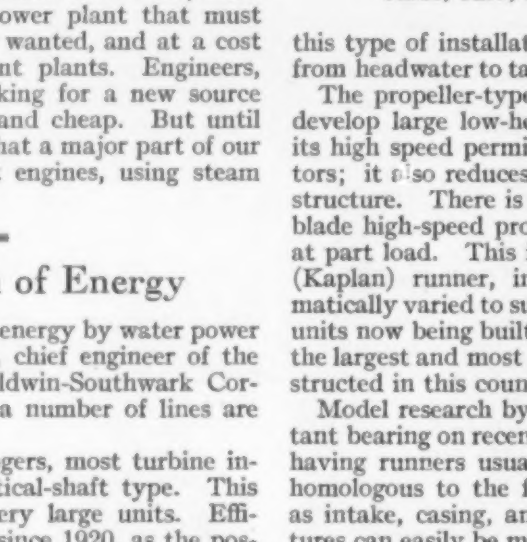
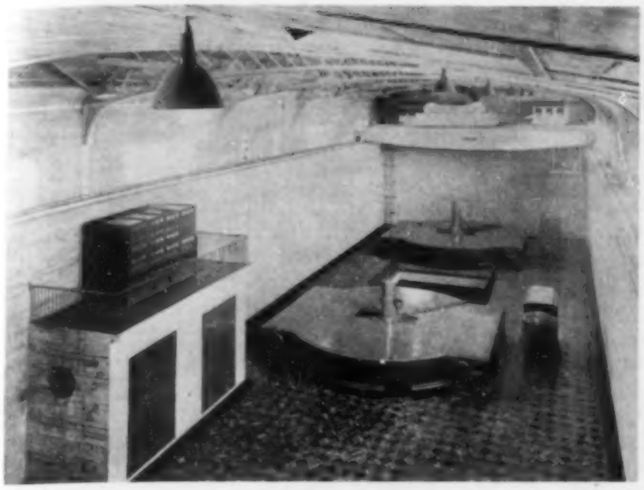


FIG. 1. THE TREND OF HYDROELECTRIC DEVELOPMENT IN THE UNITED STATES

Among important mechanical improvements of the past ten years Mr. Rogers mentioned the increasing use of stainless steel for parts subject to mechanical wear and erosive action; the use of welded steel construction in place of steel castings for guide vanes, head covers, and stay rings; the development of water-lubricated, rubber-lined bearings that are superior to the usual lignum vitae type; and the machining of blade surfaces of propeller-type turbines. The actual advantage of the latter practice has not yet been definitely determined.

An adjustable-blade propeller turbine has recently been de-



A Modern, Automatically Controlled, Medium-Head Hydroelectric Plant

veloped wherein the blades are automatically adjusted by water flowing through the unit. No interconnection is provided between the blades and the governor, which actuates the guide vanes in the customary manner. A unit of this type has recently been installed in West Virginia.

Automatic air valves are now used in many turbines. They improve operating conditions at part load, and also permit considerable saving in power when the generators are operating as synchronous condensers. In the latter case, compressed air is admitted to depress the water until it clears the runner.

Several interesting future developments were indicated by Mr. Rogers. To meet a possible demand for pumped-storage installations, he said, one company has designed and tested models which combine in one unit the pumping and generating equipment. Commercial development of units of this type will materially reduce the cost of pumped-storage plants. Efficiencies of 87 per cent in pumping and 88 per cent in generating have been obtained with one of these models.

Another promising field is the development of the propeller type for higher heads. The economic advantage of higher speed as well as the better operating characteristics of the Kaplan-type runner will certainly warrant the necessary research along these lines.

Automatic control of load distribution among units, as well as frequency control, is constantly becoming more important. Equipment has been developed for both these purposes. The use of electric clocks has also made it necessary to install devices that will correct cumulative errors caused by slight frequency changes. Further improvements and refinements in these types of equipment will undoubtedly be required in the future to meet the severe demands of the large interconnected systems.

Improvements in Energy Utilization

In introducing his subject, Joel D. Justin, M. Am. Soc. C.E., consulting engineer of Philadelphia, made a few remarks on recent trends in the market for electrical energy. Before the World War, he said, electric traction absorbed a considerable part of the power produced; at present, however, this use is of relatively minor importance. On the other hand, domestic consumption has increased from an average of 268 kwhr in 1914 to 697 kwhr for the year ending June 30, 1936. In industry more electric power and less man power per unit of product is constantly being employed. Industry, moreover, is turning to central stations as its source of supply, and today purchases about 53 per cent of all the power it uses.

Technical improvements have permitted decreasing prices, and decreased prices have led to new and wider uses. Increased production has in turn put a premium on further technical improvements, and in this manner the endless chain has operated to the benefit of consumer and producer alike.

Before the World War American communities were largely served by local companies, some of them operating steam plants and others hydro plants. The hydroelectric companies, at certain seasons of the year, had a great deal more power than they could use on their own load curves. Hence in the course of time, lines were built to industrial centers served largely by steam, in order to utilize this low-cost surplus energy. This factor was largely responsible for the development of long-distance transmission.

It was soon found that the set-up of the community power company was not usually an efficient means of handling the increasing business. Consequently combinations and absorptions led to the rapid growth of regional power companies serving extensive territories with a single unified system.

Coincident with the development of the regional power company, there was a great increase in the interconnection of systems under independent management. This resulted in many cases in reductions of operating expense and capital cost, as interconnection reduces both the capacity needed to supply the load and the capacity required for reserve. It also provides an opportunity to allocate the most efficient steam plants in the combined system to a point at or near the base of the load, where they are able to generate many more kilowatt-hours per year than they can when operating singly.

Furthermore, if some of the interconnected systems are served largely by steam plants and others largely by hydro plants, it is possible to obtain material annual savings by the better use of hydroelectric energy. For instance, in an individual system served largely by water power, the utilization factor may be between 30 and 60 per cent. When such a plant is interconnected with other systems served largely by steam, this utilization factor may exceed 90 per cent.

Supplying energy for the peak load of any power system is always expensive. It is not unusual for the top 20 per cent of the annual load curve to contain only from $^1/_2$ to 2 per cent of the total energy output of the system. If a single steam plant had no other function than to serve this part of the load curve, its annual capacity factor might be as low as 2 per cent. Old steam plants are frequently used for providing this service (see Fig. 2) for although their cost of energy production is high, they do not have to produce much energy. However, the cost of maintaining such plants, and of keeping them in "hot reserve," when there is a likelihood that their capacity may be required, is often heavy.

Hydroelectric plants with large pondage are particularly suited for performing peak-load service. The operating cost is insignificant and the incremental capital cost of installation may be less than $50 per kw of installed capacity. Consequently, it is often economical to increase the installed capacity of such plants, when favorably situated, to a point where the ratio of installation to available stream flow is very high.

The pumped-storage hydro plant is simply a special case of the peak-load hydro plant, the difference being that the pumped-storage plant does not require any water supply except to compensate for evaporation and seepage. At times of peak load the water runs from the headwater pond to turbines located on the tailwater pond. At times of low load, the off-peak, low-cost, steam-generated energy, or surplus hydro energy, flows to the plant and pumps the water back into the headwater pond. In Europe there are at least forty pumped-storage plants in successful operation, but in this country there is so far only one—the Rocky River plant in Connecticut, with an installed capacity of 25,000 kw. It is believed, however, that there are many situations where plants of this type might be useful in decreasing the total cost of peak-load service.

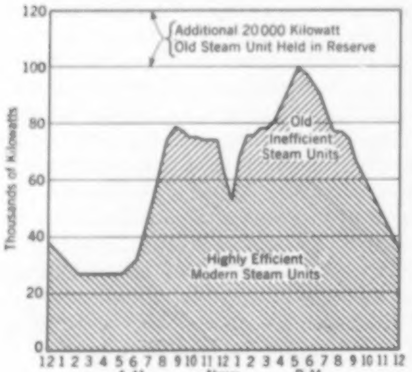


FIG. 2. TYPICAL LOAD CURVE, SHOWING ALLOCATION OF INEFFICIENT UNITS TO PEAK-LOAD SERVICE

Much more can be accomplished in improving the utilization of energy and decreasing its cost. Interconnection has often been more successful where there was an identity of ownership, and this factor will probably lead to further interconnection with actual consolidation of the properties. Among important pending technical developments might be mentioned direct-current transmission, which some electrical engineers believe will materially lower the cost of transmission.

Cost of Generation of Energy

THE COST OF generating electrical energy is only a part of the ultimate cost of that energy to the consumer, said Philip Sporn, vice-president and chief engineer of the American Gas and Electric Company. The cost of transmission and distribution is often overlooked in comparing the relative merits of power from various sources, and this has been particularly true in the current discussion of various proposed federal hydroelectric developments.

Hydraulic power is not necessarily cheap; in most cases it cannot even compete with steam power. Data published in reports of the Federal Power Commission indicate that the cost per kilowatt of installed capacity of hydro plants varies from $124 to $348. Fixed charges vary from 0.342 cents per kwhr to 4.56 cents per kwhr on the basis of a 90 per cent load factor, and from 0.380 to 1.967 cents per kwhr on the basis of a 40 per cent load factor. The true economic function of hydraulic power is doubtless to supplement steam power.

The major part of the cost of generating power at a hydro plant is the fixed charges on the investment. Operating costs, based on an annual load factor of 40 per cent, vary between 0.19 and 0.80 mills per kwhr.

The general range of cost for producing energy in steam plants has been fairly well established. For plants built prior to 1932, Mr. Sporn found that the plant investment ranged from $85 to $140 per kw of installed capacity, with the greatest number of the plants lying in the range between $100 and $110. However, the wide variation in costs prevents any rational deduction as to "average" cost.

Operating costs at a steam plant represent a higher proportion of the total cost than at a hydroelectric plant. At a load factor of, say, 30 per cent, such costs constitute about 33 per cent of the total cost of generation, while at an 80 per cent load factor they may make up 50 per cent of the total cost.

One of the most misunderstood factors in the cost of power is the cost of transmission. Those who have closely studied the problem have generally been unable to find any sound economical basis for long-distance transmission. (See Fig. 3.) In economically developed systems, transmission has generally been used largely as a means of integrating relatively small loads to take advantage of their diversity. For example, although the interconnected system of Mr. Sporn's company extends over nine states, the actual mean weighted transmission distance under normal conditions is less than 60 miles.

At a load factor of 50 per cent, the cost of transmitting power for 250 miles is approximately the same as the operating cost of generating an equal amount of power in a modern steam plant. Except for operation at very high load factors, it is in general more economical to transport coal than to transmit energy by power line for distances of more than 140 miles.

The major cost of energy for residential and general factory use is the cost of distribution. As the amount of power consumed per customer increases, these figures come down to a fairly reasonable level, running to a low of 1 to 2 cents per kwhr where the consumption is 2,000 kwhr or more per customer per year. If customer density and customer use are low, however, this cost may run as high as 10 or 20 cents per kwhr.

Another item in the total cost of power is the reserve generating equipment that must be provided to insure reliable service. On an isolated system of only one plant, as much as 50 per cent of the installed capacity (100 per cent reserve) may be required. This may double the cost of firm power at the plant. Even in interconnected systems, the reserve capacity may be 15 to 30 per cent of the total installed capacity. This reduction is in part offset by the cost of the connecting lines that make it possible.

It is difficult and perhaps unfair to compare costs between a single hydroelectric development and a steam plant. The hydro plant does not have the flexibility of the steam plant as regards load factor. That is, the latter can be designed for operation at a high load factor when new, and can be assigned to a position on the load curve of lesser and lesser use as more economical steam plants are developed. On the other hand, a hydro plant can in general be developed economically only for a certain position on the load curve. The economics of hydro generation is bound to be less and less sound as additional fuel sources are located within reach of main load centers and as the more economical sites are exhausted.

One of the best possibilities for reducing the cost of power lies in the reduction of investment costs. The trend in the cost of generating equipment has been definitely, though not sharply, downward. Installation of larger units in particular offers material opportunities for reducing costs. Another possibility is superposition in existing steam plants, though as a general rule superposition has to be handled in fairly large blocks if it is to be economical from an investment standpoint. There is at present no indication of any trend that would make

future hydroelectric developments more attractive economically than those developed heretofore.

The art of transmission has developed remarkably in the past 15 years, but there are many difficulties in the path of absolutely reliable transmission, and the costs are still high and cannot compete with other forms of transmission at long distances. No major developments tending to reduce cost are indicated at the present time in this field. The same is true as regards the distribution system.

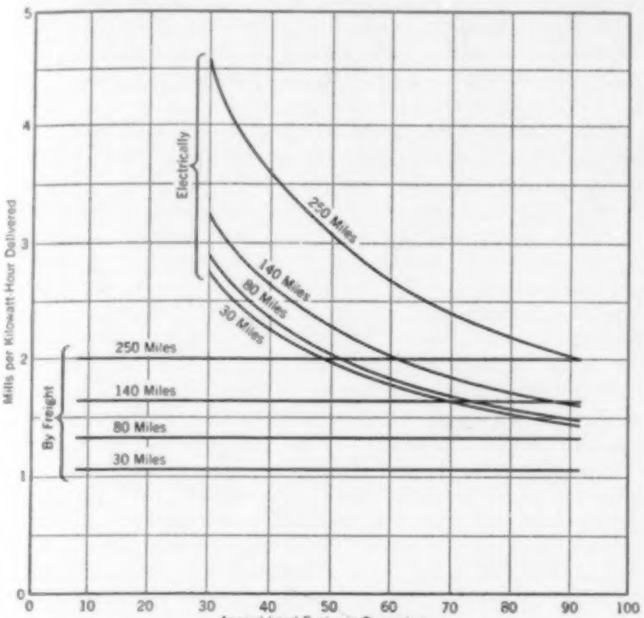


FIG. 3. COMPARISON OF COST OF TRANSMISSION OF ENERGY BY FREIGHT (COAL) AND ELECTRICALLY

It can be definitely expected, concluded Mr. Sporn, that future over-all costs of electrical energy will be lower than present costs, but the decline will probably not be rapid. Future economical development seems to lie in the direction of fairly large steam plants located at a reasonable distance from load centers and provided with interconnecting transmission.

Economic Aspects of Cheap Power

CHEAPER POWER obviously means increased economic well-being, said Prof. Ralph E. Freeman, of the Department of Economics and Social Science, Massachusetts Institute of Technology. When we reduce the human and material resources necessary to produce a unit of energy, we augment the potential amount of consumable goods at the disposal of the community.

Many people apparently fear another industrial revolution as the result of improvements in the generation of energy. The old economic problem of how to produce enough has been replaced by the new one of how to dispose of what is produced. In Mr. Freeman's opinion, a dread of superabundance is groundless. Congested markets are simply the result of unbalanced relationships between one industry and another. The delusion of plenty would be harmless did it not lead people to seek a solution in ill-advised currency, pension, and "social dividend" schemes. Conditions may occasionally exist that call for additional media of exchange, or less productive capacity in certain industries, or for a shorter work day, but the fact that such measures may be temporarily beneficial does not imply that the basic cause of economic disturbances is in a scarcity of money or a superfluity of goods.

To reduce the cost of energy generation means the further displacement of human labor in industry. On the whole such a development is socially beneficial and we need not fear that it will cause a permanent addition to unemployment. Cheaper non-human energy increases the demand for supervisory and other forms of what may be termed mental labor; it also permits men and women to enter occupations of the human-service type. There are problems, of course, but history demonstrates that they can be solved.

The direct application of steam energy to industry brought about a concentration of production and greater specialization. Will recent changes in the manner of energy generation affect these conditions? Consider, for example, the centralization of production in large plants in congested urban centers.

Since electrical power can be distributed to relatively distant points, low-cost power is being made available to small producing units. Progress in electrification may remove the advantage that steam power gives the larger manufacturing plants. However, it is not possible to predict surely that these developments will lead to a producing system of small plants dispersed over the country. It is true that a moderate amount of decentralization of industry has taken place since 1900, but in many cases the primary cause has been the possibility of hiring cheaper labor in new locations. On the other hand, the migration would in many instances have been impracticable had it not been possible to secure power in the new locations at reasonably low rates.

In recent years there has been agitation for government assistance in decentralization. Resettlement schemes and power projects have won support from those whose imaginations have been caught by the vision of a deurbanized world. There is a danger, however, that projects may be initiated that are out of harmony with fundamental economic and engineering tendencies. Financial cost should not be the only guide in such matters, but before public subsidies are expended a careful investigation should be made of the cost of the expected social benefits.

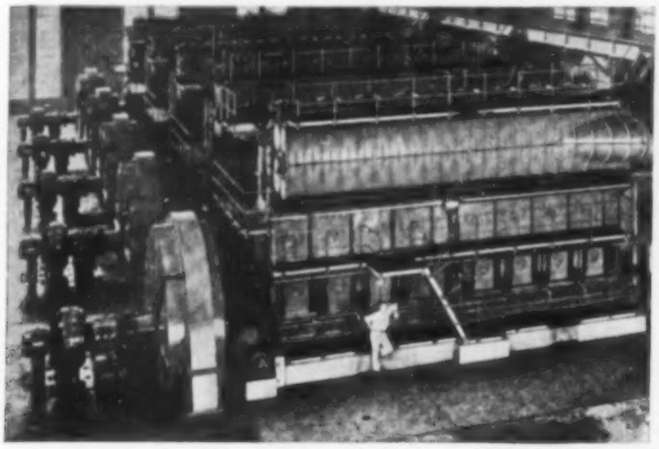
So long as we live in an economic régime that is not centrally planned and controlled, we must conform our productive activities in large measure to the dictates of prices and costs. To ignore the monetary signals is to invite chaos. In the main, prices and costs have controlled the economic activities of this country, and in many instances a departure from this control has reduced the efficiency of the economic machine.

Of course it is permissible to go behind the price structure and inquire whether prices accurately reflect the relative scarcity of resources and the wants of the community as a whole. Technically it may be argued that prices reflect the relative scarcity in the present, without taking sufficient account of the future. For example, it has been argued that the use of petroleum involves the depletion of resources that cannot be replaced, whereas the harnessing of falling water is open to no such objection. Should we modify the effects of costs and prices as determined under a private profit-seeking régime, and subsidize hydro-generation of energy in the interests of conserving natural resources?

In putting such policies into effect we must be cautious. It is hazardous to base social plans on possible future technical developments. Further, when one method of energy generation displaces another suddenly, many

plants are rendered obsolete and many persons are thrown out of work. Should this social cost be mitigated by government action regulating the rate of technical change or imposing a financial burden on the source of disturbance?

Other questions were also posed without answer by Mr. Freeman. Should farmers be given especially low rates to encourage use of electricity on farms? Should the government subsidize power projects to foster agricultural development? Such questions, he said, cannot be excluded from a discussion of the economics of energy generation.



HIGH THERMAL ECONOMY IS OBTAINED IN DIESEL INSTALLATIONS
The Engines in This Plant at Vernon, Calif., Are Rated at 6,850 Bhp Each

There is a confusion of issues in current controversy. To advocate lower rates on the ground that the resulting increase in consumption will reduce the unit cost is an economic argument that is valid within the exchange-price system. But to advocate lower rates on the ground that they will benefit certain types of consumers or stimulate certain industries is an argument that may be valid on social grounds but is outside the economic plane of prices and costs. In discussing the problem, the two types of approach are not always kept clearly in mind.

Electric Power in Economic Perspective

THE CONTROVERSY over the regulation and control of power production has obscured certain aspects of the problem that are of fundamental importance, said Prof. B. Alden Thresher, of the Department of Economics and Social Science, Massachusetts Institute of Technology. The issue between public and private operation, between more regulation and less regulation, between the Securities and Exchange Commission and the holding companies—in fact, the long running fight that has accompanied the whole half-century of growth of this industry is, when seen in true perspective, a mere incident in a larger development. That larger development consists of the simultaneous growth of supply and demand. As regards supply, we find cheap and abundant energy flexibly distributed and readily controlled. As regards demand, we find marked changes in industrial organization connected with the use of cheap power in industry, and even more spectacular changes in social habits as the retail consumer adjusts himself to power in the home.

The progress of the power industry is not so dependent upon the winds of political change as many would have us think. Behind the surface controversy over forms of organization and regulation lie the real determining factors of the problem—the technical limitations of economic production on the one hand, and the social and industrial nature of the demand on the other.

Consideration of the power industry in other countries shows that it has grown and prospered under the most diverse forms of economic organization, ranging from the extreme forms of public ownership to almost complete reliance upon private enterprise. Between these extremes is found a rich variety of intermediate forms, including mixtures of private and public participation in the same enterprise.

This shows that there are more fundamental economic forces at work than are contemplated in the terms of the controversy as it has been presented to the people of this country. Power can be successfully distributed under a wide variety of legal and economic forms. Where there is a steady and growing demand for a service, and where the technical means and the labor and capital are available, the process of production somehow gets itself organized. Whether this organization takes the form of public or private enterprise is not such a fundamental fact as one might suppose. Either form must, for survival, adapt itself to the basic economic realities of the industry. In all probability, both forms will persist side by side for many years, and each will gain through the presence of the other. We hear frequent claims that regulation has broken down. It would be more accurate to say that the concepts on which regulation in the United States is based have never caught up with the swift development of the technical and social complex that we call the power industry.

Several conditions may be recognized that make for a smooth and prompt adjustment to economic changes: (1) The commodity sold should be reasonably uniform and standardized. (2) It should be sold largely to ultimate consumers, rather than to producers of other goods. (3) It should be capable of storage. (4) Entrance into the industry should be free and should not require a heavy investment. (5) It should be possible to abandon or reduce production without heavy loss. (6) Cost should be predominantly direct, rather than of an overhead nature—this is a corollary of (4) and (5). (7) The industry should be in a state of steady but not too rapid growth. (8) Technical progress should not be so rapid that obsolescence becomes a serious problem. (9) The surrounding economy should be operating with an approximately stable level of prices.

The power industry exhibits marked divergences from this theoretical ideal. These may be classified under two heads: (1) rigidities in the market structure, centering upon the problem of overhead-cost allocation and leading to a condition of natural monopoly enforced by the technical conditions of production; and (2) dynamic elements, that is, rapid qualitative changes in technique and in demand.

Efforts to cope with these peculiarities of the industry under a body of law better adapted to a more static situation have given power companies a temporary advantage that has been wiped out by the pressure of economic change. Public regional projects on the one hand, and private consolidations and interconnection agreements on the other, though apparently opposite in policy, constitute a common response to the basic economic situation of the power industry. A policy of cooperation is therefore best calculated to further the permanent welfare of the industry.

Stream Pollution in the Ohio Basin

The Present Status of Pollution Control, and Plans for Future Development

INTEREST in the abatement of stream pollution is one of the significant trends in the field of water resources control, and the subject is of especial importance in the Ohio River basin, where almost two million persons depend for their water supply on streams highly charged with industrial wastes and the sewage of a concentrated population.

Much work has already been done in this area. Certain industrial wastes that formerly were discharged into the streams are now withheld, and at least one of them has been found to yield a valuable by-product that makes this treatment economical. Adequate sewage treatment systems have recently been installed in a number of places, and preliminary studies for a comprehensive main drainage plan for metropolitan Pittsburgh have been prepared. On the Shenango River, the Pymatuning Reservoir operates primarily to store flood waters and increase low-water flows, thus reducing the pollution load on a number of water works. Public health organizations have developed a fine technique both in making pollution surveys and in handling the emergency sanitary work that must follow every flood. Yet money for pollution abatement projects is hard to get, for such work still appears as a luxury to the average taxpayer. A public "stream pollution consciousness" must be developed before truly adequate steps can be taken.

All these factors were brought out in papers presented at the Fall Meeting of the Society on October 15, 1936, before two technical sessions sponsored by the Sanitary Engineering Division and the Cleveland Section. Because of the possibility that these papers may be treated more fully in Society publications at a later date, brief summaries only are presented here.

What Can We Do About Stream Pollution?

One of the penalties of the growth of population and industry is stream pollution, the correction of which is now being emphasized, according to Abel Wolman, M. Am. Soc. C.E., chief engineer of the Maryland State Department of Health. In each area where the situation has become acute, the time has arrived for the people to take a definite position as to the balancing of convenience in the use of the stream.

Those persons who have had least to do with the problem of pollution are prone to over-simplify the solution, while those who have struggled with the issue for years are accused of delaying progress by being too lax in the enforcement of laws, and not active enough in public education. Solutions are offered in law, in science, in finance, and in administration.

Law enforcement is frequently the first recourse of certain groups of individuals. The popular phrase, "There ought to be a law," exemplifies this faith in correction by legislative fiat. Experience discloses, however, that no greater progress in stream pollution abatement has occurred in those states where rigid legislation has been on the books for many years than where such laws are absent. It is the writer's judgment that successful pollution control does not depend primarily on the extension of legislative restriction. If the people are not ready, the law fails. Standardization of state laws on the subject, however, is desirable.

A review of the record discloses that in the field of treatment of industrial wastes there are many problems for which the answer has not yet been found. Inertia and ignorance on the part of industry have been responsible perhaps for more delay and less accomplishment in the field of stream-pollution control than any other factor. But industry's responsibility in this field cannot continue to rest on the negative resistance to extension of legislative control; it must begin to traverse the more positive paths towards the isolation of scientific and economical answers to problems of industrial waste treatment. American industry cannot afford to be accused of being unable to solve the technical problems of waste treatment, when its accomplishments in the allied fields of technological production have been as varied, as successful, and as inspiring as they have been.

In the matter of treating domestic wastes, the state of the art is sufficiently advanced to require no similar pressure. Obviously, certain technical information is still lacking, and scientific diagnoses and procedure still need to be developed, but processes of treatment are at hand that are economical and satisfactory.

The key to the primary question of what can be done about pollution lies in money. Money for pollution abatement has become increasingly difficult to raise, largely because stream pollution is too remote from the average taxpayer's eye and nose.

The experience of the last four years has indicated how important an impetus may be given to the construction of sewage treatment plants by the artificial device of federal grants-in-aid. The principle is of course not new; it has been used since the beginning of our Federation of States. An inventory of the progress of sewage-treatment-plant installation in the various states discloses that over 25 per cent of the existing plants in the country have been constructed since 1932. It is difficult to believe that this is the result of chance or of a simple natural process of growth, rather than the obvious result of the artificial stimulation of activities in this field by federal funds.

This experience leads Mr. Wolman to suggest that perhaps the most useful field for stimulation of correction of stream pollution is in the grant-in-aid principle. It need not follow, of course, that the grant-in-aid from the federal government is a prerequisite. The possibility of extending the state grant-in-aid procedure to the sanitary field is here pointed out as an opportunity for real progress. Such a procedure within the state has precedent in the fields of education, agriculture, and highways. It has the merit of continuing and preserving local autonomy and responsibility.

The permanent control of the situation lies in the cooperative effort of the public official, the private investor, and the man in the street. Intelligent appraisal of the problem and of the benefits to be derived from its solution should be the guide; hysteria and undue recriminations are not likely to produce permanent solutions.

Controlling Pollution in the Ohio River

PROGRESS IN controlling pollution in the Ohio River basin was outlined by E. S. Tisdale, director of the division of sanitary engineering of the West Virginia State Department of Health. Of the various factors in pollution, he believes, sewage is perhaps the most important, for more than 5,000,000 persons obtain their water supplies within the basin—nearly 2,000,000 of them from the Ohio River itself.

The prevailing method of municipal sewage disposal in the basin is to conduct the wastes directly to the streams without purification. Thus far the public has been protected against water-borne diseases by the skillful design and operation of water purification plants, but there are limits of pollution beyond which even the best of such plants cannot operate with safety. These limits were reached in some cases during the extreme drought periods of 1930 and 1931.

HUNDREDS OF ABANDONED MINES HAVE BEEN SEALED TO REDUCE THEIR ACID DRAINAGE

A Typical Masonry Seal with Inverted Siphon "Trap"

It is encouraging to note that since 1932 approximately $12,000,000 has been expended to improve sewage collection and disposal in five states of the basin. Most of this work has been made possible through federal aid. It is estimated that $50,000,000 more will be necessary to provide primary treatment of sewage from all municipalities on the main stem of the Ohio River.

Another encouraging factor is the policy of one state health department, which refuses permits for extensions to city sewerage systems until the city in question agrees to develop a comprehensive plan for sewage collection and treatment. If all the states of the watershed adopted such a policy, the program of reducing sewage pollution would be accelerated.

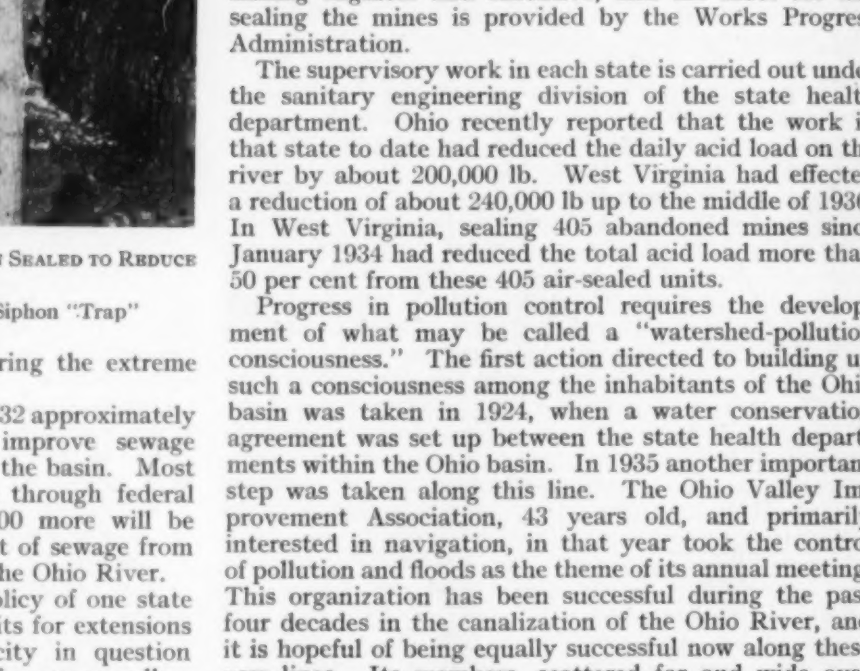
Industrial wastes are another source of contamination of Ohio River water. In dealing with such wastes two cardinal principles must be observed: (1) A common policy must be adopted throughout the entire watershed; and (2) the technical men in industry and the engineers in government service must jointly work out the solution of the problem.

These principles were well illustrated during the last decade in dealing with phenol, a tar-acid waste produced in the manufacture of coke and formerly discharged into streams, where it caused offensive odors and tastes in downstream water supplies. Under the Ohio River Interstate Stream Conservation Agreement, the health departments of Pennsylvania, Ohio, West Virginia, and Kentucky worked on this problem cooperatively, after the engineers of the U. S. Public Health Service had made a comprehensive regional survey of the situation. Remedial action was taken by the steel industry after a common policy had been worked out. Today phenol has become a valuable by-product, reclaimed rather than wasted, and this menace to public water supplies is no longer present.

Acid mine drainage constitutes the greatest single source of industrial pollution in the Ohio basin. Real progress in its elimination is being made at present through a cooperative effort of the states in the watershed and the federal government. The total acid pollution from all bituminous coal mines in the basin—active, idle, and abandoned—is estimated to amount to over 15,000,000 lb daily. Much of this comes from the abandoned group. Of 2,212 coal mines in West Virgina, for example, 1,358, or about two-thirds, are abandoned. These abandoned mines, as well as those in Ohio, Pennsylvania, and Kentucky, are being air-sealed in a well-coordinated, standardized program in operation since 1933. The program is now in charge of an experienced mining engineer and executive, and the labor for air-sealing the mines is provided by the Works Progress Administration.

The supervisory work in each state is carried out under the sanitary engineering division of the state health department. Ohio recently reported that the work in that state to date had reduced the daily acid load on the river by about 200,000 lb. West Virginia had effected a reduction of about 240,000 lb up to the middle of 1936. In West Virginia, sealing 405 abandoned mines since January 1934 had reduced the total acid load more than 50 per cent from these 405 air-sealed units.

Progress in pollution control requires the development of what may be called a "watershed-pollution consciousness." The first action directed to building up such a consciousness among the inhabitants of the Ohio basin was taken in 1924, when a water conservation agreement was set up between the state health departments within the Ohio basin. In 1935 another important step was taken along this line. The Ohio Valley Improvement Association, 43 years old, and primarily interested in navigation, in that year took the control of pollution and floods as the theme of its annual meeting. This organization has been successful during the past four decades in the canalization of the Ohio River, and it is hopeful of being equally successful now along these new lines. Its members, scattered far and wide over four states of the basin, form the nucleus for an appeal to the citizens and the legislatures of the several states to cooperate on a program of pollution abatement.



THE OHIO RIVER FLOWS THROUGH A SERIES OF FIFTY-THREE "BOXES"

In Many of the Slackwater Pools, Sewage Treatment Is Becoming Imperative to Protect Public Water Supplies

Another organization, according to Mr. Tisdale, has just recently been formed, which has already proved to be of outstanding importance. This is the Ohio Valley Planning Commission, whose permanent organization was effected in March 1936. Through its efforts preliminary plans for a pollution-control program have been worked out. The necessary resolution to allow for the formulation of an interstate compact in the Ohio River basin was passed by Congress in May 1936. Thus the groundwork has been prepared for the states to appoint commissioners to negotiate a final compact to be submitted for adoption by the several state legislatures.

The Ohio Valley is not the only watershed in the United States where interest in stream pollution is high. From various sections of the country measures were introduced in the last Congress providing for federal control of stream pollution. Many of these bills were of a drastic nature, but the ones prepared by the Cincinnati Chamber of Commerce Committee, which has been working closely with the Ohio Valley Planning Commission, were of a more moderate type. Public hearings on the Vision-Barclay bill made out a strong case for a moderate, middle-of-the-road type of stream-pollution control, placing in the U. S. Public Health Service the features of investigation, comprehensive planning, and offering financial assistance, but retaining to the states, under their police powers, the active control of pollution. Under our constitutional set-up, this appears to be the wisest type of procedure at the present time. It appears likely that a moderate measure along these lines may be passed by Congress early in 1937.

Pollution Problems at Cincinnati

THE METROPOLITAN DISTRICT centering about Cincinnati, Ohio, thoroughly appreciates that the Ohio River, during six months of the year, is grossly polluted, said J. E. Root, M. Am. Soc. C.E., director of the department of public works of Cincinnati. But however great the problem, the remedial measures cannot be accomplished by that city acting by itself. Any lack of action must be charged to the cooperative negligence of the entire metropolitan district, comprising 700,000 persons, of whom some 30 per cent reside outside the corporate limits of Cincinnati. As part of the district lies in Ohio and part in Kentucky, the solution is one not only for joint inter-city action, but for interstate cooperation.

Every investigation of river conditions from 1908 to 1930 has established the fact that the river, on arriving at the eastern edge of the metropolitan district, is already a polluted stream. In part, therefore, Cincinnati's problem is intensified by the negligence of others upstream on both the main river and its tributaries; and in part, improvement must depend upon corrective measures taken by upstream communities.

Canalization of the Ohio, at least between Cincinnati and Louisville, "has had a tendency to complicate rather than simplify the problems connected with sewage disposal, possible nuisance production, the operation of water treatment devices, and the preservation of the public health." The Cincinnati pool is created by Dam No. 37, located at approximately the westerly limits of the city. This pool extends upstream 20 miles, to about the eastern limits of the city, the business district being located about equidistant from the two dams.

A PICTORIAL MAP OF THE CINCINNATI AREA, SHOWING SOURCES OF RIVER POLLUTION

Although the Water Works Intake Is Upstream from the Sewers, It Draws from the Same Pool Into Which They Empty

For navigation purposes the crest of the downstream dam is at such an elevation that the minimum stream depth at the upper end of the pool is 9 ft. A rough estimate of the quantity of water in the pool, at a time of zero velocity, is 16,000,000,000 gal. During periods of continued dry weather the minimum stream flow may be less than 3,400 cu ft per sec. During the drought of 1930, when the average stream flow for 5 months was 5,000 cu ft per sec, the time required for water to pass through the pool averaged 56.6 hours, and during the worst month of that year (October) the time required was estimated to be in excess of 100 hours. With the sewage and the industrial and commercial liquid wastes from the metropolitan district directly or ultimately getting into the pool at times of low flow, decomposition soon takes place and offensive odors are produced. The pool, therefore, during periods of low discharge acts as a receiving and settling tank in which the natural chemical and bacteriological actions of decomposition take place. There are extended periods during the summer and early fall when the load is so great that the dissolved oxygen in the water has been completely exhausted.

The selection of possible sites for sewage treatment works at Cincinnati, Mr. Root believes, will be no small problem. The river channel in that area is of comparatively recent geological origin; the stream is narrow and the banks are steep. There are few low areas of sufficient acreage to accommodate works of the character required. In 1913, only five locations were considered as suitable; since then one of these has been appropriated by the Union Terminal and another by the municipal airport. One of the others is some 16 miles from the heart of the city. To take care of the pollution on the Ohio side of the river at Cincinnati would require works costing approximately $15,000,000.

Another factor requiring thoughtful consideration as a part of the pollution problem is that of floods. The local Weather Bureau office has records of river stages over a period of 78 years. During that period the maxi-

mum flood height was slightly over 71 ft (February 15, 1844). This height was almost duplicated in January 1913. In general, the records indicate that a flood of 60 ft or more may be expected to occur on an average of once in seven years.

Floods begin to affect the city itself at about the 50-ft elevation. During the 78-year period of record there have been 60 floods of 50 ft or over—an average of one every 16 months.

Because of the pollution of the river, the frequency of floods, and the lack of favorable sites for treatment plants, the money required to finance the necessary remedial works will amount to many millions of dollars. After construction, no mean sum will be necessary annually to provide for their satisfactory operation.

A Solution for the Problem at Pittsburgh

GREATER PITTSBURGH'S rugged topography, and its multitude of governmental jurisdictions, create one of the most complicated sewage disposal problems in the country, according to D. E. Davis, M. Am. Soc. C.E., consulting engineer (the Chester Engineers) of Pittsburgh. Along some 160 miles of shore line of the Allegheny and the Monongahela are located 116 separate municipalities with a total sewered population of about 1,200,000. Within the same area, in addition, are pro-

HUNDREDS OF SEWERS LIKE THIS POUR THEIR UNTREATED FILTH INTO THE OHIO

Discharge of the Mill Creek Intercepting Sewer at Cincinnati, Ohio

duced industrial wastes with a population equivalent of approximately the same figure.

Pollution contributed in the Pittsburgh area at times exercises harmful effects downstream. For considerable periods the bacterial counts from Wheeling, W.Va., downstream to Portsmouth, Ohio, have been among the highest in the United States. The high acid content of the Pittsburgh wastes has an interesting effect; it "pickles the bugs," so that the oxygen content of the water at Pittsburgh is much better than might be expected; however, it does not eliminate the offensive organic matter, but merely transfers it downstream for a considerable distance before natural purification processes can set in. The reduction of acid by mine-sealing and other methods may alter the present situation enough to set up a chronic nuisance and lead to a demand for a clean-up.

When federal funds were made available for various local projects in 1933, the City of Pittsburgh initiated a Metropolitan Drainage Survey for the development of a comprehensive plan for intercepting sewers and disposal of sewage in the district. It was realized that it would not be expedient for the city to attack its problem independently, and the study was extended to include the entire county, or metropolitan area. The investigation included the assembling of data on population, water consumption, sewage flows, and bacteriological analyses.

The development of the physical aspects of the plan was largely dictated by the unusual topography of the district. Recalling the 160-mile shore line, it will be realized that to concentrate the sewage at relatively few sites would involve an enormous expense for interceptors and pumping stations. It was decided to adopt drainage basins as the basic unit in the design, without respect to their relationship to administrative areas. Most of the communities extend up the hillsides back from the rivers, and their major sewers traverse the valleys of minor streams to their outlets in the Allegheny or Monongahela. Surveys revealed satisfactory sites for disposal works at or near the mouths of many of these streams, and the preliminary plan proposed the construction of not more than 36 plants. Further study may somewhat reduce this number.

Primary treatment of sewage will in general be adequate, at least as a first step. Typical primary treatment plants are planned, with provision for chlorination, but sludge beds are eliminated. The digested sludge would be delivered to barges for delivery to storage tanks at a central sludge-disposal plant equipped with vacuum drying and incineration facilities. The entire system can be constructed for less than $20,000,000, subject to some modification by later studies. By approaching the problem from a county-wide viewpoint, decided economies can be effected. In this manner, also, more expert technical supervision than would be likely in individual municipalities will be assured.

It is obvious that without the whole-hearted approval of the general public, little will be accomplished. The first job is to overcome the apathy of the electorate. Public money came forth readily for the construction of filtration plants, because the water users traced the immediate benefits to themselves in terms of health insurance. But the case for sewage purification is not made out so easily. Few communities dispose of their wastes solely from an altruistic belief that thereby they are bettering the river for the water plants of communities below. They seldom act voluntarily unless assailed by serious local nuisances, or by threat of damage suits by lower riparian owners. They prefer to spend their money for things closer to their hearts—streets, schools, and bridges.

Until the edge is taken off these pent-up demands, it is hardly surprising that the voter has not been keenly interested in sewage disposal. There is evidence, however, as Mr. Davis points out, that these primary needs have been generally satisfied in most communities, and that funds may now flow into projects formerly regarded as luxuries. Increasing leisure and its expenditure in healthful outdoor pursuits should stimulate interest in cleaner streams. The canalized rivers are essentially long, quiet, inland lakes which would become alive with recreational enthusiasts were the fear of disease removed.

The responsibility for disposing of human pollution is squarely up to the municipalities. Enabling legislation will be required similar to that called for in the "Metropolitan Plan"; it has thus far been rejected by the voters. When the public is sufficiently in earnest, the necessary legislative machinery can undoubtedly be created.

The Uses of Pymatuning Reservoir

THE USES OF Pymatuning Reservoir were described by C. E. Ryder, chief engineer of the State Department of Forests and Waters of Pennsylvania. Pymatuning Reservoir is located at the headwaters of the Shenango River, 90 miles north of Pittsburgh and 60 miles east of Cleveland. It was completed in 1934 at a cost of approximately $3,750,000.

The Pymatuning Act provides that the dam shall be so constructed and established as to conserve the water entering Pymatuning swamp and regulate the flow therefrom for the purpose of maintaining as regular a flow as possible throughout the year in the Shenango and Beaver rivers. It also provides that the reservoir may be used for recreational purposes, but that this use is secondary. It is the problem of the State Department of Forests and Waters to determine a satisfactory operating schedule and to evaluate conflicting interests.

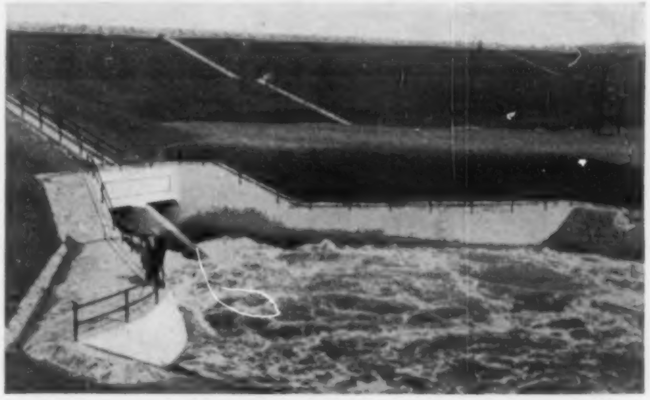
Fortunately, the area of the reservoir is so great that, at spillway elevation, a 2-ft depth will provide sufficient capacity for complete flood control under the worst known flood conditions. By providing such storage above crest elevation, the flood-control operation will have only a minor detrimental effect on the efficiency of the reservoir in regulating dry-weather flow. However, for fishing, boating, and hunting purposes, the lake level should be kept nearly constant. To release more water than is needed is therefore not desirable. Although

A PLEASING USE OF RANDOM MASONRY IN THE PYMATUNING GATE HOUSE
This View Was Taken Before the Reservoir Had Filled

the legislature was careful to define the primary use of the reservoir, it must be borne in mind that the principal interest of the project to a large majority of the people in the surrounding territory is the recreational advantages it affords. The project is rather unusual in that all three purposes can be met without materially sacrificing its usefulness for any one of them.

Communities downstream from the dam have long been in need of additional water during the months of low flow. Shortages for domestic and industrial purposes have occurred frequently, and have annually curtailed operations at some of the steel mills. Water works drawing from the Shenango and Beaver rivers serve about 175,000 persons, yet 35 miles below the dam, river discharges as low as 8 cu ft per sec have been experienced, and flows of less than 30 cu ft per sec have occurred almost yearly.

Prior to the passage of the Pymatuning Act, the State Department of Health had insisted upon the installation of sewage treatment works by all cities discharging sewage into the Beaver or Shenango above the intakes of water works. It was recognized, however, that with Pymatuning in operation the releases during dry seasons would improve the river conditions, and as a result oxidation was not required. The sewage works have therefore been constructed without provision for the



A DAM THAT "PAID FOR ITSELF" IN THE FIRST YEAR OF OPERATION
The Pymatuning Reservoir Reduced Flood Damages in March 1936, and Supplied Much-Needed Water During the Summer

high degree of treatment that would otherwise have been necessary.

A tentative operation schedule, based on a period including the recent years of extreme drought, indicates that the reservoir can maintain a minimum flow at Sharon of 200 cu ft per sec during the summer months, and 100 cu ft per sec at all times. The maximum drawdown would be in the neighborhood of 4 ft.

This year (1936) the water in the Shenango and Beaver rivers has been tested under various rates of discharge, to enable the Water and Power Resources Board to arrive at an intelligent determination of the manner in which the reservoir should be operated. Sampling stations were established at various points—14 in a distance of 87.5 miles. Tests included alkalinity and pH, dissolved oxygen, and B.O.D. determinations, and observations of color and iron content. Studies thus far made indicate that the criterion for releases will be the needs for sanitation and public water supplies, and that if these needs are met, or approximately so, there will be more than sufficient water for industrial purposes. At least 200 cu ft per sec will be required at Sharon during the summer months; winter requirements will be about half that amount.

The largest and costliest flood in the area now protected by the reservoir occurred in 1913; its magnitude and effect are comparable to that of the 1936 flood in other sections of Pennsylvania. Every town along the river, Mr. Ryder noted, was at least partially submerged. Two feet of storage above the spillway of Pymatuning Dam will hold back a similar flood in the future. This storage is provided by a 2-ft weir placed in the spillway.

Although 1936 is the first year in which the reservoir filled, benefits have at least met expectations as to the value and usefulness of the project. During the summer the Beaver River, and especially the Shenango River, showed the effects of a very dry season. During this period the average release from the reservoir was 100 cu ft per sec, and the average resulting flow at Sharon was 175 cu ft per sec. Had there been no storage, the flow could not have exceeded 30 to 40 cu ft per sec at Sharon for the greater part of the time.

The March runoff did not approach a record stage,

but did produce a secondary flood along many stretches of the Shenango River. Without the reduction in stage of this flood effected by the Pymatuning Reservoir, the damage in the valley would have been considerably greater than that which actually occurred. Consensus of opinion in the valley below the dam seems to be that the project has already paid for itself.

Sanitation Problems Incidental to Floods

ALTHOUGH flood control reservoirs can reduce maximum flood stages, and dikes can safeguard municipalities against inundation, it requires large sums of money and many years to develop such projects. Therefore, as W. L. Stevenson, M. Am. Soc. C.E., chief engineer of the Pennsylvania Department of Health, pointed out, sanitation problems incidental to floods may continue to be a health menace in unprotected places for many years.

Sanitation is the keeping clean or the making clean of the environment of man. Its principles are well known and in daily use. What creates the acute problem in flood sanitation, and makes difficult the use of these established principles, is the need for immediate, simultaneous action everywhere and the difficulties of transportation and communication.

The greatest menace to public health created by floods is the possible contamination of public water supplies when water works are inundated. Impounded upland supplies are seldom adversely affected by flood waters, and hence are to be preferred if any choice in the matter is possible. To safeguard low-lying water works there should be sufficient storage capacity for purified water to supply the locality throughout the period of the flood and afterward until the water works are safely back in service. All practicable safeguards should be provided, and where feasible, the vital parts of low-lying water works should be raised above maximum flood height. Water mains should be installed in the low-lying parts of communities subject to flooding, where the inhabitants now depend on private wells.

A sufficient number of suitably located storm, rain, and snow gages should be maintained so that government hydrographers can make reliable flood forecasts. State and local health departments should have general plans for disease-prevention work during floods.

When floods are about to occur, state health departments should notify local boards of health as to what should be done to prevent disease causable, directly or indirectly, by the flood. They should also warn water works in the flood zone to store as much purified water as possible and to adopt emergency safeguard measures at low-lying pumping stations and water filters. Health authorities should extensively and continuously warn the public in flooded areas to boil all drinking water.

AFTER THE FLOOD: THE PUBLIC HEALTH DEPENDS UPON QUICK SCIENTIFIC HANDLING OF FILTH

Government hydrographers should make and disseminate forecasts as to rising stages and flood crests, especially for the purpose, so far as sanitation is concerned, of giving water works due warning. Motorized water tanks should be mobilized to carry pure drinking water into towns where the public supply has failed, and to those where there is no public supply or where private wells have been inundated.

Large quantities of quicklime and chlorinated lime should be promptly obtained for disinfection and cleaning up when the flood waters have receded. Mobile bacteriological laboratories should be sent promptly into the flood areas for the analysis of public and private water supplies. Measures should be taken to prevent the use of contaminated milk and other foodstuffs.

When the flood waters have receded, said Mr. Stevenson, rapid but thorough cleansing and sterilizing of all flooded water works and milk stations should at once begin. No water should be supplied from flooded filters until they have been thoroughly cleansed, the water heavily chlorinated, and bacteriological analyses made which show the quality of the water to be perfectly safe. During this transition period, warnings to boil all drinking water should be continued.

Mud and debris should be promptly removed from flooded private wells, and the wells should then be pumped to waste. Next, a strong chlorine solution should be added, and the wells should be repumped and bacteriologically analyzed before the water is used for drinking purposes.

An orderly plan is needed for utilizing men, trucks, and small tools in the quick and thorough cleaning up of flooded dwellings, especially in towns. Quicklime should be used in the cellars, and chlorinated lime in the rooms of such houses. Temporary latrines should be provided in flooded towns which do not have public sewers and whose inhabitants depend upon privies.

In sanitary work for the prevention of disease during and following floods, speed, sympathy, and service are essential to success, but above all there must be hearty cooperation between those working to help the inhabitants in the stricken area and the people themselves.

These principles of sanitation for disease prevention were successfully applied in Pennsylvania during the floods of March 1936. There were no epidemics, nor was the case rate or death rate from reportable diseases transmissible by water and foodstuffs higher in the flooded areas than elsewhere. It was a dramatic but successful test of the principles of public health work.

Stream Pollution Surveys

THE GENERAL requirements of a stream pollution survey were reviewed by H. W. Streeter, M. Am. Soc. C.E., senior sanitary engineer of the U. S. Public Health Service, Cincinnati, Ohio. Such a survey should include compilation of data on rural and sewered population and growth trends in different parts of the river system, an investigation of all waste-producing industries, and the location of water intakes and sewer outlets. Data on the prevalence of water-borne diseases are also valuable. These several items fall under the ordinary field survey,

to which the hydrometric and laboratory surveys are supplementary.

The hydrometric survey provides detailed information on the amount of dilution water available at different points in the river system, and involves the establishment of gaging stations and the making of discharge measurements. The laboratory survey shows the actual conditions of pollution, with their seasonal variations. It should be designed to show conditions above and below the main sources of pollution and dilution, and the extent of natural purification in long stretches of river free from either influence.

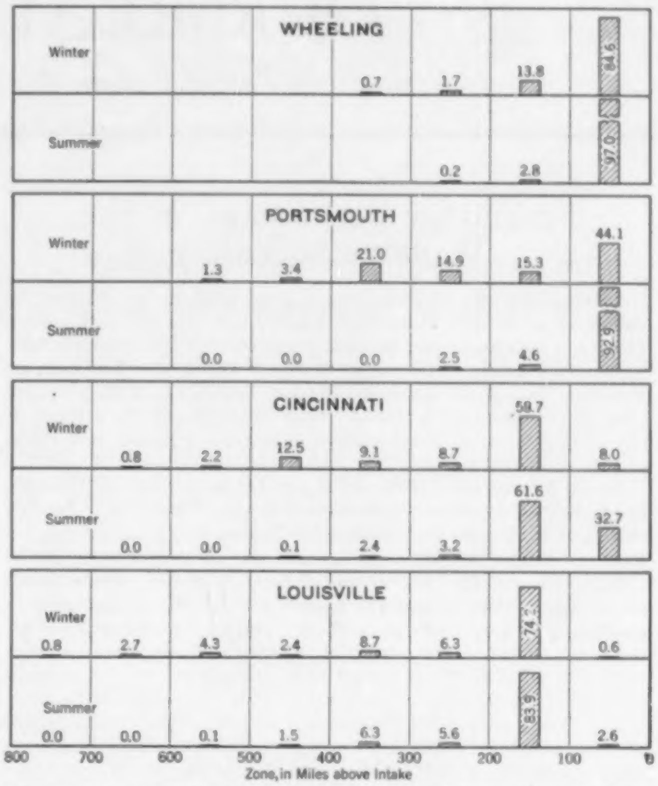
A detailed study should be made of the numbers of sewage bacteria (the *coli-aerogenes* group) and of their variations from day to day. Systematic observations should be made of the dissolved oxygen and B.O.D. at every major sampling station. Determinations of nitrite and nitrate content, and of turbidity and alkalinity are also important in many cases. For each survey, the particular tests required should be determined after consideration of the uses to be made of the water and of the particular undesirable substances that may be present. A fairly thorough biological survey is also advisable. If the sewage pollution in a river does not exceed 5,000 *coli-aerogenes* bacteria per 100 cc, satisfactory drinking water should be obtainable with the aid of efficient modern water-purification systems. Judged by this criterion, the raw waters at a number of points along the Ohio River are already definitely overpolluted. In order to support normal aquatic life, which is vital in maintaining natural purification and the general fitness of the stream for recreational uses, a certain minimum oxygen content is necessary. A fair figure for this minimum appears to be about 3 ppm. Neither of these requirements is rigid enough to meet even the more lenient of the various bathing-water standards. It is a debatable question whether the greatly added expense of restoring a polluted river to a condition safe for bathing throughout its entire course is economically justifiable.

During 1930 and 1931 a re-survey of the Ohio River from above Cincinnati to below Louisville was carried out by the Public Health Service, to determine the effects on pollution of the then recently completed canalization. The observations showed that with canalization, during summer periods of low water the conditions at water intakes located in long, unpolluted stretches were improved, but that during freshets, when accumulations of sludge were flushed out of the channel, conditions were much worse than could have been expected under continuous open-channel flow. It appeared that near large centers of population the main effect of canalization during low-water periods had been to move the critical zone of pollution-density upstream toward these centers.

It is important to determine the relative effects that various population groups have on conditions at points downstream. A method for "stepping down" the polluting effect of such groups located in successive river zones above a given point has been worked out, and was applied in the Ohio survey. Among the more striking indications of this analysis noted by Mr. Streeter may be mentioned:

1. Under both summer and winter conditions of temperature and flow, a very large proportion of the total bacterial pollution of the river at the various water intakes probably originates in wastes discharged within zones of 200 river miles or thereabouts above these intakes.

2. Pollution originating at more distant points upstream is a considerably larger factor in the condition on the river at these intakes during the winter than in summer, though it appears to be outweighed at all times by pollution from more immediate sources.



Percentage Contribution of Upstream Population Groups to Bacterial Pollution at Four Ohio River Points

Note That a Large Part of the Pollution at Each Point Originates in Wastes Discharged Within the First 200 Miles Upstream

3. Acid wastes in the upper river do not appear to exert much influence on the bacterial condition of the river at Portsmouth or further downstream, but are a powerful factor near Pittsburgh, where in the absence of sewage treatment the present acid condition of the river undoubtedly has prevented an intolerable overburdening of water purification systems through bacterial pollution.

These considerations would indicate that efforts to reduce overpollution at various water intakes, or to prevent it, would logically be aimed primarily at sources of wastes discharged within about 200 river miles above these points, and secondarily at more important sources (such as the Pittsburgh-Wheeling district) further upstream. As the general ill effects of acidity in the upper river demand that this condition be eliminated, or minimized, its present local advantage must be considered as only temporary and as hardly justifying continuance of excessive sewage pollution of the river by Pittsburgh and other cities in this zone.

Before any final program of corrective measures in the Ohio River basin is undertaken, thorough study should be given to the question of adapting degrees and methods of sewage and industrial waste treatment to the various requirements to be met in relieving over-pollution of the river in different zones. These methods, in so far as sewage is concerned, may range from sedimentation and simple chlorination to complete biological oxidation, with chemical treatment possibly falling into an intermediate position. Consideration also needs to be given to the possible effects of various treated effluents below their points of discharge, particularly in pooled sections under summer conditions.

OUR READERS SAY—

In Comment on Papers, Society Affairs, and Related Professional Interests

Feasibility of Storage in the Willamette Valley

To the Editor: Irrigation on a large scale in the Willamette Valley is basically dependent on storage on the tributaries. There are two major factors that make storage for irrigation economically feasible in the basin of the Willamette. The first, as stated by George E. Goodwin, M. Am. Soc. C.E., in the October issue, is the fact that a storage reservoir there may be utilized in the joint interest of flood control, navigation, power, irrigation, and stream purification.

In the Mississippi Valley and the states bordering the Atlantic, floods may be expected at almost any season of the year. For this reason, it is obvious that a reservoir constructed for flood control purposes should not be made to serve any other purpose. However, this is not the case in the Willamette Valley, where floods occur only in winter and low water prevails during the summer months. An inspection of a 56-year precipitation record for Albany, Ore., located in the heart of the valley, shows that of a mean precipitation of 41.60 in., only 6.38 in. occurred in the five months from May to September, inclusive. This is in marked contrast to conditions east of the Continental Divide, where over a period of years precipitation during the summer months has been greater than during the winter. Even more conclusive is a 40-year continuous hydrograph for the Willamette River at Albany, which shows that the river has not at any time during this period reached a bank-full stage of 70,000 cu ft per sec in the months from May to October, inclusive.

The economic significance of this is the fact that storage reservoirs, built primarily in the interest of flood control, may be filled by the rains and melting snows of spring, after being kept empty or partially empty during the winter months. The water thus stored will then be available for irrigation. Also, the water on its way from the storage reservoirs to the irrigable areas may be used to develop power through heads aggregating some 2,000 ft and thus help to reduce the cost of water for irrigation. Further advantages are that the storage reservoir may be made of somewhat greater capacity than is required for flood control alone and the water so impounded used to generate power, to increase the flow of the Willamette River in the interest of navigation, and to effect stream purification by doubling the low-water discharge of the summer months. This would not greatly increase the cost of the reservoir.

Another favorable factor is the almost indefinite life of the reservoirs of the Willamette basin due to the relative absence of silt. The importance of this factor is apparent when the proposed reservoirs are contrasted with other large reservoirs in the United States, particularly those in the Southwest. This situation in the Willamette Valley is due to the prevalence of igneous rock, slight soil covering, and an almost continuous expanse of virgin forest over the drainage areas above the proposed storage dams. In fact, silt is not found in the tributaries of the Willamette River except for a relatively small amount of volcanic ash brought down by the North Santiam from the southwesterly slope of Mt. Jefferson and an insignificant amount received by the McKenzie from the westerly slope of the Three Sisters. Even after the forest is logged off or burned, brush and second growth effectively protect the soil of the higher areas.

At the present time the U. S. Engineer Department is making an extensive survey of the possibilities of utilizing the water resources of the Willamette Valley. From the study it is possible to outline a general plan for the development of these resources, though not to state whether it would now be economically justified. As seen in its broad outlines, the development would make possible the regulation of floods; an increase in the low flow at Salem from a present mean low discharge of about 3,000 cu ft per sec to 6,500 cu ft per sec, thereby benefiting navigation and effecting stream purification; the generation of 245,000 kw of firm power in 12 power plants with an aggregate installed capacity of 455,000 kw and a supply of water for irrigating one million acres of highly fertile agricultural land.

Milo P. Fox
Lt. Col., Corps of Engineers,
U. S. Army, District Engineer,
First Portland District

Portland, Ore.
December 5, 1936

Beauty in Park Design

Dear Sir: In his article, "Long Island State Parks and Parkways," in the November 1936 issue, Sidney Shapiro, Assoc. M. Am. Soc. C.E., has given us accurate insight into the location, planning, and statistical data of these parks and parkways. His description of the outstanding features of this great park system identifies him as an engineer, for he goes thoroughly into the statistics involved in the roads, bridges, and other engineering features but omits almost entirely an aspect that is as important to the engineer as to the layman—the intrinsic beauty of these parks in their landscaping, and the location and architectural treatment of their structures.

Water Tower at Jones Beach Is Illuminated at Night

The type of beauty in each different park varies, of course, with the kind of people it will cater to and the functions it is to perform. In such parks as Montauk and Hither Hills there is an obvious natural beauty. Since these parks have not been artificialized to any extent, they are a rendezvous for people who like to go "back to nature." They have been preserved practically as nature made them. In contrast to these, there are the artificially beautified parks, of which Jones Beach and Bethpage parks are striking examples. It is this latter class to which I refer particularly.

When one enters any of these "artificial" parks, he is immediately impressed by the treatment of each structure within the park as well as by the combined beauty of the structures as a group in their relationship to the park. It is this individual beauty that makes an immediate impression on the visitor and lures him into the park to see it as a whole. For example, as one enters Jones Beach from Wantagh Causeway or from Ocean Parkway, the dominant object that strikes one's eye is the water tower. This structure, shown in the accompanying photograph taken at night, has all the requisites for impressing the visitor to this resort. Its architectural treatment, its location and surrounding pools, and its lighting at night make it an outstanding feature in the park.

First impressions are highly important, and those responsible for the excellent first impressions offered in the Long Island State Parks, as well as for the lasting impressions that the parks as a whole make, should certainly be commended.

George J. Viertel, Jun. Am. Soc. C.E.
Construction Superintendent,
M. Shapiro and Son

New York, N.Y.
December 5, 1936

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Eighty-Fourth Annual Meeting

New York, N.Y., January 20–23, 1937

Program of Sessions, Entertainment, and Trips

Business Meeting, Prize Awards, Conferring of Honorary Membership, and Presentation of John Fritz Medal

WEDNESDAY—January 20, 1937—Morning

Auditorium

9:00 **Registration**

10:00 **Eighty-Fourth Annual Meeting called to order by**

Daniel W. Mead, *President, American Society of Civil Engineers; Professor Emeritus, Hydraulic and Sanitary Engineering, University of Wisconsin; Consulting Engineer*, Madison, Wis.

Report of the Board of Direction

Report of the Secretary

Report of the Treasurer

10:30 **Presentation of Society Medals and Prizes**

The Norman Medal to Daniel W. Mead, *President, American Society of Civil Engineers; Professor Emeritus, Hydraulic and Sanitary Engineering, University of Wisconsin; Consulting Engineer*, Madison, Wis., for Paper No. 1902, "Water-Power Development of the St. Lawrence River."

The J. James R. Croes Medal to Wilbur M. Wilson, *M. Am. Soc. C.E., Research Professor, Structural Engineering, University of Illinois*, Urbana, Ill., for Paper No. 1900, "Laboratory Tests of Multiple-Span Reinforced Concrete Arch Bridges."

The Thomas Fitch Rowland Prize to A. V. Karpov, *M. Am. Soc. C.E., Designing Engineer, Hydraulic Department, Aluminum Company of America*, Pittsburgh, Pa., and R. L. Templin, *M. Am. Soc. C.E., Chief Engineer of Tests, Aluminum Company of America*, New Kensington, Pa., for Paper No. 1895, "Model of Calderwood Arch Dam."

The James Laurie Prize to Paul Baumann, *M. Am. Soc. C.E., Junior Assistant, Chief Engineer, Los Angeles County Flood Control District*, Los Angeles, Calif., for Paper No. 1908, "Analysis of Sheet-Pile Bulkheads."

The Collingwood Prize for Juniors to Clinton Morse, *Assoc. M. Am. Soc. C.E., Junior Engineer, The Panama Canal*, Balboa Heights, Canal Zone, for Paper No. 1901, "Renewal of Miter-Gate Bearings, Panama Canal."

11:00 **Conferring of Honorary Membership**

Alex Dow, *M. Am. Soc. C.E., President, The Detroit Edison Company*, Detroit, Mich. Mr. Dow will be presented to the President by Henry E. Riggs, *Vice-President, Am. Soc. C.E., Honorary Professor, Civil Engineering, University of Michigan*, Ann Arbor, Mich.

G. H. Duggan, *M. Am. Soc. C.E., Chairman of the Board, Dominion Bridge Company, Ltd., and Dominion Engineering Works*, Montreal, Que., Canada. Mr. Duggan will be presented to the President by J. M. R. Fairbairn, *M. Am. Soc. C.E., Chief Engineer, Canadian Pacific Railway*, Montreal, Que., Canada.

Robert Hoffmann, *M. Am. Soc. C.E., Consulting Engineer, Public Works, City of Cleveland*, Cleveland, Ohio. Mr. Hoffmann will be presented to the President by Edward P. Lupfer, *Vice-President, Am. Soc. C.E., Consulting and Contracting Engineer*, Buffalo, N.Y.

J. B. Lippincott, *M. Am. Soc. C.E., Consulting Hydraulic Engineer*, Los Angeles, Calif. Mr. Lippincott will be presented to the President by H. W. Dennis, *Vice-President, Am. Soc. C.E., Chief Civil Engineer, Southern California Edison Company*, Los Angeles, Calif.

J. A. L. Waddell, *M. Am. Soc. C.E., Consulting Engineer*, New York, N.Y. Mr. Waddell will be presented to the President by Thomas E. Brown, *M. Am. Soc. C.E., Consulting Engineer*, New York, N.Y.

11:30 **Presentation of John Fritz Medal to**

Arthur N. Talbot, *Past-President and Honorary Member, American Society of Civil Engineers.*

Introduction of Arthur S. Tuttle, *Past-President, Am. Soc. C.E., Chairman, John Fritz Medal Board of Award.*

Statement by Chairman Tuttle on history and purpose of the medal.

Address on achievements of the medalist by Alonzo J. Hammond, *Past-President, Am. Soc. C.E.*

Presentation of the John Fritz Medal to Arthur N. Talbot by Harry P. Charlesworth, *Past-President, American Institute of Electrical Engineers*, and chairman of the board that made the award.

12:00 **New Business**

Report of Tellers on Canvass of Ballot for Officers

Introduction of President-Elect and New Officers

12:30 **Luncheon**

Fifth floor, Engineering Societies Building. Tickets $1.00 each.

Assist the Committees by Registering and Obtaining Tickets Early

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General Meeting, Student Conference, Reception to President, Honorary Members, and John Fritz Medalist

GENERAL MEETING

Résumé and Discussion, Water Resources Committee Report

AUDITORIUM

WEDNESDAY, January 20, 1937—Afternoon

Given a country of 130,000,000 people scattered over millions of square miles, with too much water unharnessed in one place and too little to perpetuate economic life in another, what should an enlightened nation do about it? During the last three years, the President's Committee on Water Flow, the Mississippi Valley Committee of the PWA, and the Water Planning Committee of the National Resources Board have paved the way for developing a regional perspective on water resources, by defining principles of control and developing inventories of hydrologic data.

The next step in an orderly water reconnaisance has just been completed by the Water Resources Committee of the National Resources Committee. It represents perhaps the first comprehensive review of national drainage basins in this or any other country. Although carried out under the direction of the Water Resources Committee, it was made possible only through the cooperative efforts of federal, state, and local official and unofficial agencies.

The Drainage Basin Study discloses the principal water problems of the country, the broad integrated patterns of water development and control designed to solve these problems, and specific construction and investigation projects as elements of the integrated plan.

No fixed or final water plan is possible. Discussion on the present findings, therefore, by the most competent members of the engineering profession, is essential for continuing adjustment of drainage-basin policies and programs. The task of fitting a ten-year program in water resources development into a long-term pattern for each river basin in the United States has been started. Upon public support and evaluation, lay and technical, rests the future success of this first effort. How may this framework proposed for a national water plan be best extended on sound lines?

2:30 Résumé of Report of Water Resources Committee of the National Resources Committee

ABEL WOLMAN, *M. Am. Soc. C.E., Chief Engineer, State Department of Health*, Baltimore, Md.

3:15 Discussion

(1) Drainage Basin Study

F. H. FOWLER, *M. Am. Soc. C.E., Consulting Civil Engineer*, San Francisco, Calif.

(2) Red River Studies

W. W. HORNER, *M. Am. Soc. C.E., Consulting Engineer*, St. Louis, Mo.

(3) Upper Rio Grande Investigations

PROF. H. H. BARROWS, *Chairman of the Department of Geography, University of Chicago*, Chicago, Ill.

(4) Collection and Publication of Basic Hydrological Data

THORNDIKE SAVILLE, *M. Am. Soc. C.E., Professor, Hydraulic and Sanitary Engineering, and Dean, College of Engineering, New York University*, New York, N.Y.

4:00 General discussion

STUDENT CHAPTER CONFERENCE

WEDNESDAY—January 20, 1937—Afternoon

3:00 Called to order by

SANFORD KORETSKY, *Chairman, Conference of Metropolitan Student Chapters*

3:02 Address of welcome by a member of the Society's Committee on Student Chapters

3:07 Response by Gerard Shannon (Manhattan College)

3:10 Address by the President of the Society

3:25 Round-table discussion in charge of

D. BRESSI (Columbia University):

"What should be the function of a Student Chapter on a university campus? How should the activities of a Chapter of a national professional society differ from those of a college social club or other campus organization?"

4:00 General discussion

4:10 Two papers prepared and presented by students, with discussion from the floor

4:40 Address by

E. M. HASTINGS, *Member, Committee on Student Chapters*

5:00 Adjournment, followed by collation and smoker

DINNER, RECEPTION, AND DANCE

WEDNESDAY—January 20, 1937—Evening

Hotel Roosevelt

COMMITTEE: EMIL PRAEGER, *Chairman;* W. D. BINGER, E. DEV. TOMPKINS, and RICHARD H. LUDEMAN

7:00 Assembly

7:30 Dinner

9:30 Reception to the President, the Honorary Members, and the John Fritz Medalist

10:00 Dancing

This function will be held at the Hotel Roosevelt, Madison Avenue and 45th Street, the Grand Ballroom to open at 7:00 p.m., and the dinner to be served promptly at 7:30 p.m.

Arrangements have been made for tables seating ten persons, and members may underwrite complete tables. Orders to underwrite a table must be accompanied by check in full and a list of guests.

Tickets will be $5.00 each. Tickets for Juniors, for the dance only, will be $2.00 per couple.

The seating for the dinner dance list will close at 5:00 p.m., Tuesday, January 19, 1937. Those who purchase tickets after that hour will be assigned to tables in the order of their purchase. Tickets will be on sale at Society Headquarters until 5:00 p.m., Wednesday, January 20, 1937.

Sessions of Technical Divisions

© Wide World Studio

LARGEST HINGELESS SINGLE-ARCH SPAN IN THE WORLD—HENDRIK HUDSON MEMORIAL SPAN, NEW YORK, N.Y.

Sessions of Technical Divisions Occupy Entire Day

THURSDAY—January 21, 1937—Morning

POWER DIVISION

The Executive Committee of the Division feels that the greatly increased and widespread general interest in the subject of power, displayed during the past few years, renders it highly desirable at this time to consider the future course of the Division. It is therefore planned to have a free and open discussion of this subject and to that end a large attendance of members of the Division is earnestly desired.

10:00 **Survey of Past Activities of Power Division**

LYNNE J. BEVAN, *M. Am. Soc. C.E., Consulting Engineer*, New York, N.Y.

10:30 **The Future Course of the Power Division**

FORD KURTZ, *M. Am. Soc. C.E., Hydraulic Engineer, J. G. White Engineering Corporation*, New York, N.Y.; *Secretary, Executive Committee, Power Division.*

11:00 **General discussion**

HIGHWAY DIVISION

10:00 **The Objective of the State-Wide Highway Planning Surveys**

H. S. FAIRBANK, *Esq., Chief, Division of Information, U. S. Bureau of Public Roads*, Washington, D.C.

10:30 **The Influence of Major Highway Improvements on Traffic Accidents**

A. H. VEY, *Esq., Traffic Engineer, Division of Traffic Control and Regulation, Department of Motor Vehicles*, Trenton, N.J.

11:00 **Influence of Henry Hudson Parkway on New York-Westchester County Traffic**

JAY DOWNER, *M. Am. Soc. C.E., Consulting Engineer*, New York, N.Y.

11:30 **Discussion**

SANITARY ENGINEERING DIVISION

10:00 **Water Softening Plant Design**

W. H. KNOX, *M. Am. Soc. C.E., Assistant Engineer, State Department of Health*, Columbus, Ohio.

10:45 **Surge in Water and Sewer Tunnels**

ARTHUR B. MORRILL, *M. Am. Soc. C.E.*, and HARRY KALLGREN, *Esq., Associate Civil Engineers, Department of Public Works*, Detroit, Mich.

11:15 **Report of Committee on Water Supply Engineering**

THOMAS H. WIGGIN, *M. Am. Soc. C.E., Consulting Engineer*, New York, N.Y., *Chairman*.

11:45 **Business session**

Entertainment for the Ladies—Smoker for the Men

Sessions of Technical Divisions

THURSDAY—January 21, 1937—Afternoon

STRUCTURAL DIVISION

2:30 The Design and Construction of a Steel-Pile Pier in Tropical Ocean Water at Puerto Armuelles, R.P.

E. L. DURKEE, *M. Am. Soc. C.E., Assistant Engineer, Bethlehem Steel Company,* Bethlehem, Pa., and T. J. BARNETT, *Esq., Chief Engineer, United Fruit Company,* Boston, Mass.

3:00 Summary of Paper by Messrs. Harold E. Wessman and Shortridge Hardesty on Related Functions of Cable and Stiffening Truss in Suspension Bridges

HAROLD E. WESSMAN, *Assoc. M. Am. Soc. C.E., Professor of Structural Engineering, College of Engineering, University of Iowa,* Iowa City, Iowa.

3:10 Lecture and Motion Picture Film on the Construction of the San Francisco–Oakland Bay Bridge

C. F. GOODRICH, *M. Am. Soc. C.E., Chief Engineer, American Bridge Company,* Pittsburgh, Pa.

CITY PLANNING DIVISION

2:30 Rural Zoning as an Adjunct to State Highway Improvement

LAURANCE J. CARMALT, *M. Am. Soc. C.E., Consulting Engineer,* New Haven, Conn.

2:50 Discussion opened by

J. J. DARCY, *Esq., District Engineer, Department of Public Works, State of New York,* Babylon, N.Y.

RUSSELL V. BLACK, *M. Am. Soc. C.E., Planning Consultant,* New Hope, Pa.

W. D. HEYDECKER, *Esq., Director of State Planning,* Albany, N.Y.

JACOB L. CRANE, JR., *M. Am. Soc. C.E., Consulting Engineer,* Chicago, Ill.

3:30 Need of, and Some Practical Methods of, Rezoning Urban Areas

HUGH E. YOUNG, *M. Am. Soc. C.E., Chief Engineer, Chicago Plan Commission,* Chicago, Ill.

3:50 Discussion opened by

ROBERT D. KOHN, *Esq., Architect,* New York, N.Y.

HARLAND BARTHOLOMEW, *M. Am. Soc. C.E., Consulting Engineer,* St. Louis, Mo.

MYRON D. DOWNS, *Esq., Engineer, City Planning Commission,* Cincinnati, Ohio.

ARTHUR L. VEDDER, *Assoc. M. Am. Soc. C.E., Secretary City Planning Board,* Rochester, N.Y.

4:30 General discussion

SANITARY ENGINEERING DIVISION

2:00 Sewage Treatment at Cleveland

GEORGE B. GASCOIGNE, *M. Am. Soc. C.E., Consulting Sanitary Engineer,* Cleveland, Ohio.

2:45 Discussion opened by

HARRISON P. EDDY, *Past-President, Am. Soc. C.E., Consulting Engineer,* Boston, Mass.

ROBERT HOFFMANN, *Hon. M. Am. Soc. C.E., Consulting Engineer, Public Works, City of Cleveland,* Cleveland, Ohio

3:00 Economics of Sewage Treatment

GEORGE J. SCHROEPFER, *Assoc. M. Am. Soc. C.E., Assistant Chief Engineer, Minneapolis–St. Paul Sanitary District,* St. Paul, Minn.

3:30 Discussion opened by

FREDERIC BASS, *M. Am. Soc. C.E., Consulting Engineer, Professor of Municipal and Sanitary Engineering, University of Minnesota,* Minneapolis, Minn.

CHARLES GILMAN HYDE, *M. Am. Soc. C.E., Consulting Sanitary and Hydraulic Engineer; Professor of Sanitary Engineering, University of California,* Berkeley, Calif.

3:45 Sewer Maintenance—an Engineering Problem

RAYMOND R. RIBAL, *Assoc. M. Am. Soc. C.E., Office Engineer, City of Oakland,* Oakland, Calif.

4:15 Discussion opened by

EARL DEVENDORF, *Assoc. M. Am. Soc. C.E., Associate Director, Division of Sanitation, State Health Department,* Albany, N.Y.

4:30 Deoxygenation and Reoxygenation

CLARENCE J. VELZ, *Assoc. M. Am. Soc. C.E., Acting Chief Engineer, PWA,* New Jersey Office, Newark, N.J.

4:50 Discussion opened by

EARLE B. PHELPS, *Esq., Professor, College of Physicians and Surgeons, Columbia University,* New York, N.Y.

H. W. STREETER, *M. Am. Soc. C.E., Senior Sanitary Engineer, U. S. Public Health Service,* Cincinnati, Ohio.

NIGHT VIEW OF SAN FRANCISCO–OAKLAND BAY BRIDGE

Entertainment for the Ladies—Smoker for the Men

THURSDAY—January 21, 1937

Afternoon and Evening

FASHION SHOW, TEA, AND ENTERTAINMENT

COMMITTEE: H. M. HALE, *Chairman;* R. W. SAWYER, 3D, and GEORGE G. HAYDEN

3:00 **Fashion Show and Tea**

Through the courtesy of the management, the ladies will be entertained at Wanamaker's, Broadway at 9th Street, where a special fashion show of smart clothes for daytime, active and spectator sports, and formal wear will be held. There will be music by one of New York's most prominent débutante orchestras.

Tea will be served following the show.

During the entire day, the Woman's Clubhouse at John Wanamaker's will be at the disposal of the ladies. The morning may be spent visiting Wanamaker's Winter Village, the Ship Shop, and other places of interest. Luncheon may be had at one of the store's three restaurants.

8:30 **Theater party at the Center Theater, Rockefeller Center, "White Horse Inn," a musical extravaganza**

Single tickets $1.00 each. Additional tickets $1.65 each.

A block of seats has been reserved for this performance and it is necessary to return all unsold tickets on Wednesday evening, January 20. Therefore, in order to be certain of reservations, checks in payment should accompany orders for theater tickets.

Evening

SMOKER AND ENTERTAINMENT

COMMITTEE: E. W. STEARNS, *Chairman;* E. R. NEEDLES, WALDO G. BOWMAN, and GEORGE L. CURTIS

Place—The Manhattan, 311 West 34th Street (34th Street near Eighth Avenue)

Time—8:00 p.m.

The committee has made arrangements for a larger hall so that members will be able to meet friends and renew acquaintances. There will be no speaker but there will be a brief program of entertainment. An orchestra will be provided to promote singing and good fellowship throughout the evening. There will be abundant refreshments and smokes.

Tickets for the smoker and evening's entertainment are free to members. Guest tickets are $2.00 each.

Friday Excursion to Include Inspection of Large Planning Improvements in the Metropolitan Area

Triborough Bridge, Wards Island Sewage Disposal Plant, Henry Hudson Bridge, West Side Park and Railroad Improvements Among Points of Interest

COMMITTEE: C. W. BRYAN, JR., *Chairman;* S. J. OTT, GLENN S. REEVES, and CHESTER L. DALZELL

FRIDAY—January 22, 1937—All Day

10:00 Members, ladies, and guests of the Society will leave in heated buses from Engineering Societies Building, 33 West 39th Street, promptly at 10:00 a.m. This excursion is planned to give a comprehensive view of some of the major projects in the plan for coordinating the traffic and other facilities for Metropolitan New York.

On leaving Society Headquarters, the excursion will proceed northward, passing the site of the Queens Tunnel, thence over the Queensboro Bridge on Queens Boulevard to the neighborhood of Forest Hills, L.I. The buses will then enter the newly constructed Grand Central Parkway and travel by the site of the 1939 World's Fair, thence along Flushing Bay where the municipal airport (North Beach Airport) may be seen. The excursion will then go over the Triborough Bridge and approaches, where an opportunity will be available for seeing the Wards Island Sewage Disposal Plant and Randalls Stadium.

Back on Manhattan again, the excursion will proceed northward, affording views of Bronx Park, the Botanical Gardens, and Van Cortlandt Park. About noon the group will arrive at Arrowhead Inn for luncheon.

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THE GEORGE WASHINGTON BRIDGE, NEW YORK

© Wide World Studio

THE TRIBOROUGH BRIDGE, NEW YORK

Following luncheon, the party will again board the buses and follow the Henry Hudson Parkway, crossing over the newly constructed Henry Hudson Bridge spanning the Spuyten Duyvil into Riverside Drive, points of interest along the route being the George Washington Bridge Riverside Church, Grant's Tomb, and the West Side Park and railroad improvements. Members interested may disembark at the West Side Park and railroad improvements for an inspection of the work, which includes some of the largest of rigid-frame structures. Again boarding the buses, the excursion will traverse Riverside Drive and the West Side Elevated Highway, arriving at Society Headquarters about 4:00 p.m.

Tickets for the excursion, including luncheon, are $2.50.

College Reunions Throughout the Week

Alumni Gatherings Scheduled for Visiting Engineers

THURSDAY—January 21, 1937

Brown Engineering Association

The Brown Engineering Association will hold an informal luncheon meeting at the Hotel Bristol, 129 West 48th Street, New York, N.Y., on Thursday, January 21, 1937, at 12:15 p.m. All Brown alumni are invited. The charge will be 50 cents per cover. Please notify H. D. Wilson, Secretary, Room 807, 180 Varick Street, New York, N.Y. (phone, Chelsea 3-1000, ext. 1073) as to attendance.

Luncheon of Chi Epsilon Honorary Civil Engineering Fraternity

Members of Chi Epsilon, their families and their friends, are again extended a cordial invitation to attend a very informal luncheon at the Midston House (Cornell Club Building), 22 East 38th St., New York, N.Y., Thursday, January 21, 1937, at 1:15 p.m.

Those interested should file advance notice with R. I. Land, 10th Floor, 100 East 42d Street, New York, N.Y. (phone, Ashland 4-3300, ext. 194), or H. T. Larsen, Room 1607, Engineering Societies Building, New York, N.Y. (phone, Pennsylvania 6-9220).

For the luncheon a charge of 90 cents per person will be made. It is hoped that as many Chi Epsilon members as possible, with their friends, will remember this date.

Luncheon of M. I. T. Engineers

All M. I. T. Alumni are invited to a luncheon at the Technology Club of New York, on Thursday, January 21, 1937, at 12:30 p.m., at the club rooms, 22 East 38th Street, New York, N.Y. Please notify the Technology Club (Caledonia 5-1475) as to attendance.

Lafayette College Civil Engineers' Dinner

All civil engineers of Lafayette College are invited to attend an informal dinner on Thursday, January 21, 1937, at 6:00 p.m., in the Grill Room of the Happiness Restaurant, 6 East 39th Street, New York, N.Y. If possible, come at 5:30 p.m. The charge will be $1.10 per cover. If you plan to attend, please notify William R. Wolff, 80 Centre Street, New York, N.Y.

Lehigh University Alumni Dinner

A cordial invitation is extended to all Lehigh members of the Society to attend an informal dinner to be held at the Midston House (formerly the Fraternities Club), 22 East 38th Street, New York, N.Y., on Thursday, January 21, 1937, at 6:15 p.m. The dinner will be over in time to permit attendance at the Society's smoker. Dinner will cost $1.75.

Please promptly notify Alexander Potter, 50 Church Street, New York, N.Y., if you can be present. Come right to the Hotel from your afternoon engagement, as there will be members present as early as 5:30 p.m. Bring any other member whose other engagements will not conflict.

Rensselaer Engineers' Dinner

An informal gathering of Rensselaer engineers is to be held at the Building Trades Club, 2 Park Avenue, New York, N.Y. (between 32d and 33d Streets), at 5:45 p.m. on Thursday, January 21, 1937.

Dinner will be served at 6:00 p.m. ($1.50 per cover) and will adjourn in time for attendance at the Society's annual smoker. All Rensselaer men and their guests are invited. This includes the ladies. Reservations should be made with Glenn S. Reeves, M. Am. Soc. C.E., 111 Eighth Avenue, New York, N.Y.

University of Illinois Engineers' Dinner

All University of Illinois engineers and their friends are invited to the Ninth Annual Informal Dinner-Reunion at the Hotel Woodstock, 127 West 43d Street, New York, N.Y., on Thursday, January 21, 1937, at 5:45 p.m., in grill adjoining main lounge.

The dinner will cost $1.15 and will be over in time for guests to attend the Society's smoker. If you plan to attend, please notify Bruce Johnston, 421 Engineering Building, Columbia University, New York, N.Y.

University of Pennsylvania Civil Engineers' Dinner

The Eighteenth Annual Informal Dinner of the University of Pennsylvania Civil Engineers will be held at the University of Pennsylvania Club, 37 East 36th Street, New York, N.Y., on Thursday, January 21, 1937, from 6:00 to 7:30 p.m. The dinner fills in the time from the end of the technical session at 5:00 p.m. until the commencement of the smoker at 8:00 p.m. Dinner will be served at 6:00 p.m. sharp, in the main dining room of the club.

The charge per cover will be $1.10. Any further information can be obtained from Albert B. Hager, Care, Atlantic Gulf and Pacific Company, 15 Park Row, New York, N.Y.

University of Wisconsin

The University of Wisconsin alumni will hold a dinner on Thursday evening, January 21, 1937, at 6:30 p.m., at the Town Hall Club, 123 West 43d Street, New York, N.Y., in honor of Prof. Daniel W. Mead, President of the Society, and Dean F. E. Turneaure, Honorary Member. F. E. Schmitt, M. Am. Soc. C.E., Editor, *Engineering News-Record*, is chairman of the dinner. Reservations should be made direct to R. Worth Vaughan, 31 Nassau Street, New York, N.Y. (Rector 2-2260). Tickets $1.75.

FRIDAY—January 22, 1937

Brooklyn Polytechnic Institute Dinner

The graduates of Brooklyn Polytechnic Institute who are members of the Society will hold their annual reunion dinner at the Chalfonte Hotel, 200 West 70th Street, New York, N.Y., at 8:00 p.m., on Friday, January 22, 1937.

The charge per cover will be $1.25. Notify Michael A. Imperiale, 202 Sixth Avenue, Brooklyn, N.Y. (Telephone South 8-7447), regarding attendance.

Dinner of Columbia Engineers

The graduates of Columbia University who are members of the Society will meet for their sixteenth informal dinner on Friday, January 22, 1937, at 6:30 p.m., at the Columbia University Club, 4 West 43d Street, New York, N.Y. The principal speaker will be Carlton S. Proctor, M. Am. Soc. C.E., of Moran and Proctor, who will discuss foundation problems of the World's Fair Site at Flushing. The charge will be $1.50 per cover. Address communications to J. K. Finch, Columbia University, New York, N.Y.

Harvard-Princeton-Yale Joint Meeting

The Annual Huddle of the graduate engineering bodies of Harvard, Princeton, and Yale will be held at the Yale Club, 50 Vanderbilt Avenue, New York, N.Y., on Friday evening, January 22, 1937, at 8:00 p.m., with Yale Engineering Association as host. The evening will be given to fraternizing and music. Speaking will be limited to signal calling while members of each team will play in the back fields of the others. The Hammond Organ will be demonstrated and a short talk on its technical features will be given. No charge will be made.

New York University Annual Alumni Reunion Dinner

There will be an annual reunion dinner for the alumni of New York University at Keen's English Chop House, 72 West 36th Street, New York, N.Y., on Friday, January 22, 1937, at 7:00 p.m. Meet at 6:30 p.m. for social hour. Please apply to E. C. LaValley, New York University, Box 188, University Heights, New York, N.Y. Dinner will cost $1.25.

Thayer Society of Engineers of Dartmouth College

The annual meeting and dinner of the Thayer Society of Engineers of Dartmouth College will be held at the Dartmouth College Club, New York, N.Y., at 6:30 p.m., Friday, January 22, 1937. Notify the Dartmouth College Club, 24 East 38th Street, New York, N.Y., as to attendance.

SATURDAY—January 23, 1937

Clarkson College Alumni Dinner

The annual dinner of the Clarkson College Alumni Association will be held at the Midston Club, 22 East 38th Street, New York, N.Y., on Saturday, January 23, 1937, at 6:30 p.m. Notify Frank C. Boes, 38 Cypress Street, Floral Park, N.Y., as to attendance.

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VIEW OF SITE OF WILLIAMSBURG HOUSING PROJECT

Trips to Points of Engineering Interest

SATURDAY—January 23, 1937—Morning

10:00 **Inspection Trips**

As these trips all start about the same hour, it will not be possible to participate in more than one. Members will proceed individually to the rendezvous point named for the trip selected, so as to arrive at the time given. Arrangements have been made for visits to the following points of interest:

1. American Museum of Natural History
2. New York Museum of Science and Industry
3. Williamsburg Housing Project
4. Hell Gate Power Station
5. Commerce Building, Port of New York Authority

American Museum of Natural History

Members and guests taking this trip will be conducted through the newly opened African Hall with its 14 large habitat groups of the larger African mammals, lifelike in their natural habitat of vegetation, topography, and other environmental features. They are true to life in every detail and represent the highest development of the taxidermist's art. Thence to the Dinosaur Hall with its great fossil skeletons of the denizons of a long past geological age. The party will then pass through the Fossil Reptile, Fossil Mammal, and Age of Man halls to the Morgan Hall of Minerals and Gems, with its beautiful specimens of crystals, precious and semi-precious gems, and an exhibit showing the extraordinary effect of ultra-violet light on fluorescent minerals.

Members of the party will then be free to visit any of the other Museum exhibition halls that they choose, have luncheon in the Museum restaurant, or visit the Hayden Planetarium.

New York Museum of Science and Industry, R.C.A. Building, Rockefeller Center

The Museum of Science and Industry, formerly known as the Museum of Peaceful Arts, is gaining wide attention as one of the city's attractions.

The Museum, which is now an endowed institution, is a new type of industrial museum whose 2,000 exhibits depict outstanding discoveries and experiments in science. More than 400 of these exhibits can be operated or set in motion with the push of a button, the pull of a lever, or the turn of a crank. Temporary exhibits record the most recent achievements of notable scientific and industrial laboratories.

It is open daily from 10:00 a.m. to 10:00 p.m. Admission tickets are 25 cents.

Other attractions of Radio City and Rockefeller Center, which, including the Museum of Science and Industry, may be visited daily, are:

Radio City NBC Studio Tour

A backstage visit through the National Broadcasting Studios—a complete tour of the world's largest and most modern broadcasting plant in action. Tickets 40 cents.

Rockefeller Center Guided Tour

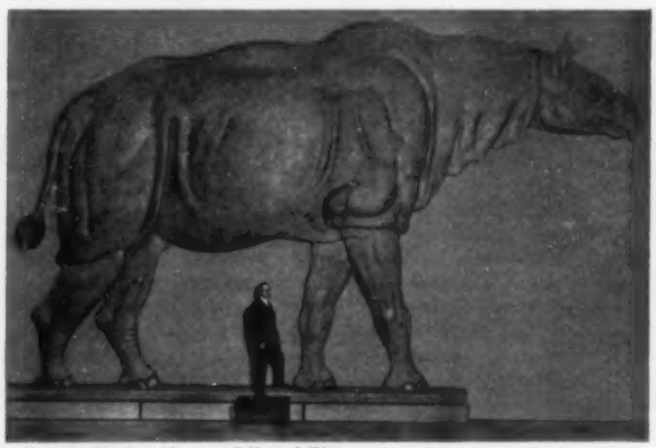
A tour of the buildings, comprising Rockefeller Center (except the NBC Studio Building) with a description of the art and architectural features and the history of the project, including a visit to the observation roofs. Tickets $1.00.

Observation Roofs of Rockefeller Center

Located seventy stories above the street atop the R.C.A. Building in Rockefeller Center, the roofs offer an excellent view of the metropolitan area of New York and an unexcelled view of Central Park and uptown points of interest. Tickets 40 cents.

Courtesy N.Y. Museum of Science and Industry

GENERAL ELECTRIC EXHIBIT



Courtesy American Museum of Natural History

JOHN S. HOPE WITH HIS MODEL OF BALUCHITHERIUM

Hotel Accommodations and General

The Trip to Bermuda

Saturday Trips

Hell Gate Power Station

Through the courtesy of the New York Edison Company, Inc., a visit has been arranged to the Hell Gate power station of the company, located on the East River at 134th Street. It has a capacity of 605,000 kw, of which 105,000 kw delivers a 25-cycle current at 11,000 v and the remainder, 500,000 kw, delivers 60-cycle current at 13,800 v. There are 26 boilers with a total steam capacity of 7,030,000 lb per hr, of which 5 have powdered-fuel furnaces and 21 have mechanical stokers.

This station has high-tension tie connections with all other power plants of the New York Edison Company, Inc., and also with the Hudson Avenue station of the Brooklyn Edison Company. It also has a connection with the Upstate Niagara Hudson system, which is operated at 132,000 v. This high-tension tie connection has a capacity of 150,000 kw in either direction.

It is from this station that current is delivered to the New York Central for the operation of its electric zone between the Grand Central Station and Harmon.

The coal is delivered by 5,000-ton steamers, and a storage of approximately 20,000 tons is maintained. The average daily consumption is 2,500 tons.

To reach this station, take the Lexington Avenue subway express to East 138th Street and then go east on the 138th Street crosstown car to the end of the line.

Williamsburg Housing Project

Plans for the $12,500,000 PWA financed Williamsburg Housing project call for the construction of 18 groups of four-story fireproof brick apartment buildings, providing 1,463 two-, three-, four-, and five-room apartments. These plans were prepared by the architects of the New York City Housing Authority under the general supervision of the PWA Housing Division.

A striking feature of the plan of the Williamsburg houses is the grouping of the buildings "askew" on the general site plan, by which more rooms will receive more sunlight more hours a day. In addition, the area available for parks and lawns will be much larger.

The development may be reached by taking the B. M. T. Canarsie Line subway to Grand Street and walking two blocks south to the Project Office at 152 Ten Eyck Street.

Commerce Building, Port of New York Authority

The Port Authority Commerce Building, the largest structure on Manhattan Island, is 15 stories high, 800 ft long, and more than 200 ft wide. The building is sufficiently large in area and flexible enough in its services to enable an organization great or small to conduct its business on one floor, including executive and clerical forces, manufacturing and processing units, display rooms, stock and shipping departments. Among the many innovations, the building has four of the largest high-duty elevators ever built, with platforms 17 by 34 ft.

Members taking this trip will go directly to the building at 111 Eighth Avenue, where they will be met and conducted through the structure. The Seventh and Eighth Avenue subways or the Ninth Avenue elevated to 14th Street, Manhattan, are convenient.

General Announcements and Hotel Accommodations

Railroad Rates

Special convention fares on the certificate basis were discontinued when the general reduction in railroad rates became effective. Since rates are not the same throughout the country, consult your ticket agent regarding special rates and routings.

Facilities of Engineers' Club

For the convenience of out-of-town members, arrangements have been made for members to use the dining facilities of the Engineers' Club on a cash basis. Guest cards for this purpose may be obtained at the Registration Desk. The club will also be able to accommodate a limited number of members, the price of rooms ranging from $2.50 upward. Requests for reservations should be made in advance and addressed to Society Headquarters.

Information Desk

An information desk is provided in the Reading Room of the Society on the fifteenth floor of the Engineering Societies Building to assist visiting members in obtaining hotel reservations and theater tickets, and in securing any desired information about the city. Their attention is called to the facilities of the Reading Room (open Tuesday, Wednesday, and Thursday), for meeting friends, writing letters, and receiving mail. All members are welcome to inspect and utilize the quarters of the Society.

Your New York Address

At the Registration Desk a card file of those in attendance will be maintained, with information as to members' hotel addresses in New York. Members are requested to keep Headquarters informed as far as possible of their New York addresses so as to expedite the delivery of telegrams, telephone messages, and mail.

Order All Tickets in Advance

Members who order tickets in advance will not only be saved annoyance and delay by having tickets and badges awaiting them on arrival at Headquarters, but they will assist the committee greatly by giving advance information to guide it in concluding arrangements. Ticket order blanks have been mailed to each member with the condensed program.

No cancellation of tickets can be made after noon of Wednesday, January 20, 1937.

SANITARY ENGINEERS' MEETINGS, DINNER, AND INSPECTION TRIP

THURSDAY—January 21, 1937—All Day

The Sanitary Engineering Division of the Society extends a cordial invitation to members of the New York State Sewage Works Association to attend the sessions of the Sanitary Engineering Division on Thursday.

Following the sessions, members of the two groups will hold a joint dinner at the Hotel McAlpin, Broadway and 34th Street, New York, N.Y. Time, 6:30 p.m. Price of tickets, $2.50 each.

Reservations for tickets should be made not later than January 20, 1937, through H. Burdett Cleveland, M. Am. Soc. C.E., Consulting Sanitary Engineer, 235 Naples Terrace, New York, N.Y.

FRIDAY—January 22, 1937—All Day

The Annual Meeting of the New York State Sewage Works Association will be held at the Hotel McAlpin. All members of the Sanitary Engineering Division are invited to attend.

SATURDAY—January 23, 1937—Morning

Inspection of New Coney Island Sewage Treatment Plant

Through the courtesy of the New York Department of Sanitation, members of the New York State Sewage Works Association and the Sanitary Engineering Division will have the opportunity of inspecting the newly completed sewage treatment plant at Coney Island.

The party will leave the 34th Street entrance of the Hotel McAlpin by automobile promptly at 9:10 a.m. and return about 1:00 p.m.

Reservations for the trip are to be made through William Raisch, 27th Floor, 155 East 44th Street, New York, N.Y.

Hotel Accommodations and General Announcements

Hotel Accommodations

In order to be certain of accommodations, members are urged to make definite arrangements for rooms at least a week in advance of the Annual Meeting, paying for the rooms in advance for at least a part of the period during which they expect to be in New York.

Hotel Rates

Hotels	Without Private Bath: Single Room	Without Private Bath: Double Room	With Private Bath: Single Room	With Private Bath: Double Room
Roosevelt	.....	.....	$4.00 up	$6.00 up
Astor	.....	.....	3.50 up	5.00 up
Barclay	.....	.....	5.00 up	8.00 up
Biltmore	.....	.....	5.00 up	7.00 up
Chatham	.....	.....	4.00 up	7.00 up
Commodore	.....	.....	3.00 up	4.50 up
Governor Clinton	.....	.....	3.00 up	5.00 up
Lexington	.....	.....	3.50 up	5.00 up
McAlpin	2.50 up	4.00 up	3.50 up	5.00 up
Murray Hill	2.00 up	3.00 up	2.50 up	3.50 up
New Yorker	.....	.....	3.50 up	5.00 up
Pennsylvania	.....	.....	3.50 up	5.00 up
Plaza	.....	.....	6.00 up	8.00 up
Savoy-Plaza	.....	.....	6.00 up	8.00 up
Taft	.....	3.00 up	2.50 up	4.00 up
Vanderbilt	.....	.....	3.50 up	6.00 up
Waldorf-Astoria	.....	.....	6.00 up	9.00 up
Woodward	.....	.....	2.50 up	3.50 up

NOTE: The Hotel Roosevelt, at which the reception, dinner, and dance will be held, will care for reservations to the extent of its capacity.

Special Hotel Accommodations

For the convenience of members, arrangements have been made with a number of hotels to furnish accommodations at daily rates which include breakfast, as follows:

Hotels	Single Room With Bath and Breakfast	Double Room With Bath and Breakfast (for 2)	Suite 2 Rooms with Bath and Breakfast (for 2)
Hotel Earle	$2.50	$3.50	$5.00
Hotel Holley	2.50	3.50	5.00
Hotel Van Rensselaer	2.50	3.50	5.00
Hotel Le Marquis	2.50	3.50	5.00
Hotel Wellington	3.00	4.50	6.00
Hotel Woodstock	3.50	5.50	6.50
Hotel Vanderbilt	3.75	6.50	11.50

Those interested in the above arrangement should communicate directly with Miss Mary Barry, 103 Waverly Place, New York, N.Y.

Introductions for Visiting Members

Members who, during their attendance at the Annual Meeting, wish introductions or meetings with engineers in New York City, may call on the Secretary's Office for any service desired.

GROUNDS OF HOTEL BERMUDIANA, BERMUDA
Society Group Will Stay Here

The Trip to Bermuda

Members have already received notice of another trip to Bermuda following the Annual Meeting.

The ship, the *Monarch of Bermuda*, is one of the handsomest and best equipped that enters New York. Likewise, Bermuda is modern. The Bermudiana Hotel is the equal of any hotel anywhere. Its golf courses rival the best in America or Europe. Its shops contain a great variety of English goods at very attractive prices.

F. S. Lincoln

SCENE ALONG THE WATERFRONT, BERMUDA

The U. S. Customs permits one to bring back a hundred dollars' worth of foreign goods duty free.

The cruise includes a stop of three days. The visit may be extended if desired. The discounts are liberal; they are good for a stopover, too, and offer real savings from the regular tariff.

The popularity of Bermuda at this time of year makes it necessary for members and their friends to decide early. Make your deposit and hold your cabin if there is a chance that you will go. You may cancel later if you must and your deposit will be returned.

Write to the Secretary, 33 West 39th Street, New York, N.Y., for full information.

Regional Meeting Committee

This program has been prepared under the direction of the Regional Meeting Committee: Edward P. Lupfer, Vice-President, Am. Soc. C.E., Chairman; and O. H. Ammann, James K. Finch, Carlton S. Proctor, and C. E. Trout, Directors, Am. Soc. C.E.

Committee on Local Arrangements for the Annual Meeting

DAVID BONNER, *Chairman*
C. W. BRYAN, JR., *Vice-Chairman*

WALTER D. BINGER	EMIL PRAEGER
WALDO G. BOWMAN	GLENN S. REEVES
HERBERT M. HALE	ROBERT W. SAWYER, 3D
E. R. NEEDLES	E. W. STEARNS
S. J. OTT	E. DEV. TOMPKINS

Junior Members

GEORGE L. CURTIS	GEORGE G. HAYDEN
CHESTER L. DALZELL	RICHARD H. LUDEMAN

Ladies Committee

MRS. LOUIS C. HILL, *Honorary Chairman*
MRS. WILLIAM J. SHEA, *Chairman*

MRS. O. H. AMMANN	MRS. E. R. NEEDLES
MRS. W. D. BINGER	MRS. S. J. OTT
MRS. DAVID BONNER	MRS. GEORGE H. PEGRAM
MRS. VAN TUYL BOUGHTON	MRS. J. P. H. PERRY
MRS. W. G. BOWMAN	MRS. MALCOLM PIRNIE
MRS. C. W. BRYAN, JR.	MRS. EMIL PRAEGER
MRS. LINCOLN BUSH	MRS. CARLTON S. PROCTOR
MRS. J. K. FINCH	MRS. GLENN S. REEVES
MRS. WILLIAM MCK. GRIFFIN	MRS. ROBERT RIDGWAY
MRS. HERBERT M. HALE	MRS. RALPH R. RUMERY
MRS. JOHN P. HOGAN	MRS. ROBERT W. SAWYER, 3D
MRS. LESLIE G. HOLLERAN	MRS. GEORGE T. SEABURY
MRS. OTIS E. HOVEY	MRS. OLE SINGSTAD
MRS. GEORGE L. LUCAS	MRS. JOHN R. SLATTERY
MRS. EDWARD P. LUPFER	MRS. E. W. STEARNS
MRS. DANIEL W. MEAD	MRS. E. DEV. TOMPKINS
MRS. THADDEUS MERRIMAN	MRS. CHARLES E. TROUT

MRS. ARTHUR S. TUTTLE

Please call on the Committee on Local Arrangements or on the Secretary's Office for any service desired.

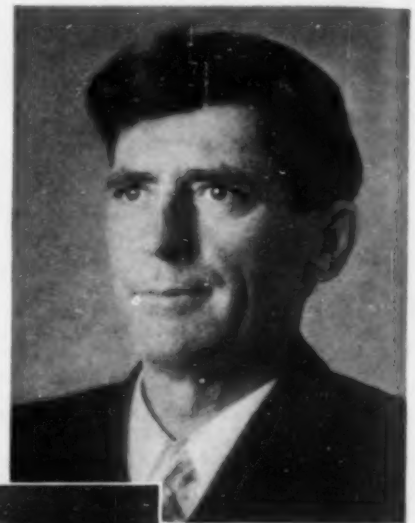
SOCIETY AFFAIRS

Official and Semi-Official

1936 Prize Winners and Medalists

DANIEL W. MEAD

Norman Medal for Paper, "Water-Power Development of the St. Lawrence River"



WILBUR M. WILSON

J. James R. Croes Medal for Paper, "Laboratory Test of Multiple-Span Reinforced Concrete Arch Bridges"

A. V. KARPOV R. L. TEMPLIN

Thomas Fitch Rowland Prize for Paper, "Model of Calderwood Arch Dam"

PAUL BAUMANN

James Laurie Prize for Paper, "Analysis of Sheet-Pile Bulkheads"

CLINTON MORSE

Collingwood Prize for Juniors for Paper, "Renewal of Miter-Gate Bearings, Panama Canal"

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Prizes and Medals to Be Presented at Annual Meeting

One of the interesting features of the Annual Meeting of the Society, to be held in New York City, January 20–22, 1937, will be the annual presentation of prizes and medals. The oldest of these Society awards is the Norman Medal, which was endowed in 1872 by the late George H. Norman, M. Am. Soc. C.E., for an original paper that is considered an especially notable contribution to the engineering profession. The J. James R. Croes Medal, which was established by the Society in 1912, was named for the first recipient of the Norman Medal. This prize is awarded for a paper considered second in merit to that receiving the Norman Medal.

In 1884 the late Thomas Fitch Rowland, Hon. M. Am. Soc. C.E., endowed the prize bearing his name, to be awarded for a paper which best describes in detail some accomplished works of construction. For the paper considered second in merit to the Thomas Fitch Rowland Prize, the Society in 1912 established the James Laurie Prize, which was named in honor of its first President.

The Collingwood Prize for Juniors was established in 1894 by the late Francis Collingwood, M. Am. Soc. C.E., on his retirement as Secretary of the Society. Papers eligible for this prize must describe an engineering work or record an important investigation with which the writer has been connected. Excellence of style is a factor in the selection of the paper receiving this prize.

Biographical sketches of those receiving prizes or medals follow.

In This Issue . . .

Paul Baumann, M. Am. Soc. C.E., graduated from the Federal Institute of Technology in Zurich, Switzerland, in 1918, with the degree of civil engineer. His studies, which he began in 1911, were interrupted in 1913 and 1914 by military training, by work as a draftsman, and by a period as lieutenant in the engineering corps upon the mobilization of the Swiss army during the World War. Upon graduation, he entered the employ of the Force Motrice Bernoise in connection with preliminary surveys, studies, and designs of the Grimsel power plant, and later worked as structural designer with H. Haenni, builder and contractor in Bern. In 1920 Mr. Baumann came to the United States, where for a year he was employed as surveyor, designer, and chief designer by the Beckman and Linden Engineering Company, of San Francisco, on dams, power plants, and canals of the Paradise Verde project in Arizona. From 1921 to 1925 he was in the employ of the Arrowhead Lake Company, Lake Arrowhead, Calif., as designer, office engineer, and resident engineer on townsite and subdivision development, including buildings, water, power, and sewer systems, and roads and bridges. From August 1925 to May 1926 he traveled through the United States, Canada, and Europe, studying dams, automatic gates, and power plants; and from June 1926 to October 1934 he was employed as designer and chief designer with Quinton Code and Hill-Leeds and Barnard, consulting engineers of Los Angeles, on hydraulic, structural, and waterfront engineering. Since the latter date, he has been assistant chief engineer of the Los Angeles County Flood Control District in charge of the mountain work, including the San Gabriel Dam project.

A. V. Karpov, M. Am. Soc. C.E., a naturalized American citizen of Russian birth, is a graduate of the Technical University at Darmstadt, Germany, and of the Technical Institute at Charkov, Russia. Since coming to the United States in 1920, Mr. Karpov has been engaged in designing work and technical investigations of various kinds, in New York, Pittsburgh, and Boston, principally in the fields of stress analysis and hydroelectric developments. He is largely responsible for the material and methods of testing used in the model of Calderwood Dam and the second model of Boulder Dam. In 1929 he went to Europe to study the advance in hydroelectric practice and to visit a number of hydro-power developments, laboratories, and manufacturing plants. Several reports and papers emphasizing the necessity of extended cavitation studies were a result of this trip. Mr. Karpov is connected with the Aluminum Company of America in Pittsburgh, although recently he has been designing two arch dams in Virginia, for Chas. T. Main, Inc., of Boston. His previous connections include the West Penn Power Company and the City of Pittsburgh. Mr. Karpov has published a number of technical papers, and is active in the affairs of the profession. As chairman of the Pittsburgh Section's Committee on the 1936 Fall Meeting of the Society, he was actively in charge of this successful meeting. He is a member of the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the Society of American Military Engineers, the Engineers' Society of Western Pennsylvania, the American Mathematical Society, and the American Association for the Advancement of Science.

Daniel W. Mead, President and Hon. M. Am. Soc. C.E., was born in Fulton, N.Y., on March 6, 1862, and graduated from Cornell University in 1884, with the degree of C.E. He was with the U. S. Geological Survey in 1884 and 1885; served as city engineer of Rockford, Ill., from 1885 to 1887; and was chief engineer and general manager of the Rockford Construction Company, from 1888 to 1896. Since 1896 he has acted as consulting engineer on hydraulic works and power plants. In 1904 he was appointed professor of hydraulic and sanitary engineering at the University of Wisconsin, holding this chair continuously for 28 years. Dr. Mead is a member of the firms of Mead and Seastone, of Madison, Wis., and of Mead and Scheidenhelm, of New York City. He was a member of the Red Cross Commission to China, on flood protection of the Huai River, in 1914; and consulting engineer of the Miami Conservancy District from 1913 to 1920. In 1928 President Coolidge appointed him to the Colorado River Board to pass on the plans for the Boulder Canyon Project. At present he is a member of the board respresenting the federal government in connection with the construction work of the Chicago Sanitary District. He has served the Society on a number of committees, notably those concerned with engineering education and Mississippi River flood control. He is also a member of the American Society of Mechanical Engineers, the American Water Works Association, the New England Water Works Association, the American Institute of Consulting Engineers, the Wisconsin Engineering Society, and the American Association for the Advancement of Science, and holds the grade of Fellow in the American Institute of Electrical Engineers.

Clinton Morse, now Assoc. M. Am. Soc. C.E., received his engineering education at the University of Minnesota. He was employed from 1925 to 1927 in the office of the county surveyor, Blue Earth County, Minnesota, on water, sewer, and drainage projects. Since 1927 he has been continuously employed by The Panama Canal, Balboa Heights, Canal Zone. He has been engaged on various construction projects in the Zone, including the Madden Dam and locks-overhall programs. Part of 1935 and 1936 was spent in further study at the University of Minnesota. At various times he has been in charge of the Subsection of Surveys of The Panama Canal, a division whose work is similar to that of the U. S. Coast and Geodetic Survey. He is at present employed as assistant engineer for the Constructing Quartermaster, engaged on townsite rebuilding projects in the Canal Zone.

R. L. Templin, M. Am. Soc. C.E., graduated from the University of Kansas in 1915 with the degree of bachelor of science in civil engineering and was a research fellow in the University of Illinois Engineering Experiment Station from 1915 to 1917, receiving the degree of master of science in theoretical and applied mechanics in the latter year. In 1926 he received the professional degree of mechanical engineer from the University of Kansas. During his summer vacations he obtained practical experience in the copper mines at Morenci, Ariz.; on railroad maintenance of way with the Atchison, Topeka and Santa Fe Railroad Company in Colorado

and New Mexico; and in structural engineering with the Kansas City Terminal Company, at Kansas City, Mo. In 1917 he was called to government service in the U. S. Bureau of Standards, where he worked on tests of materials and structures as well as on the design of test apparatus. At the beginning of 1919, he left the service of the government to become chief engineer of tests for the Aluminum Company of America, at New Kensington, Pa., which position he still holds. In this capacity, Mr. Templin is responsible for the mechanical testing, standards, methods, and apparatus used in all the laboratories of the company and its subsidiaries. He is a Member of the Society, of the American Society for Metals, the Engineers' Society of Western Pennsylvania, and of the honorary fraternities, Tau Beta Pi and Sigma Xi. He is the author of a number of technical papers on materials, testing methods, and tests of engineering structures, and in June 1934 was awarded the Charles B. Dudley Medal by the American Society for Testing Materials for meritorious research in testing materials.

WILBUR M. WILSON, M. Am. Soc. C.E., was born near West Liberty, Iowa, July 6, 1881, and graduated from Iowa State College with the degree of bachelor of mechanical engineering in 1900, and from Cornell University with the degree of master of mechanical engineering in 1904. He also received the professional degree of civil engineer from Iowa State College in 1914. He was a member of the mechanical engineering faculty at Iowa State College from 1901 to 1907, except for one year when he held the Sibley graduate fellowship in mechanical engineering at Cornell University. He practiced structural engineering in Chicago from 1907 to 1913. In the latter year he joined the civil engineering faculty of the University of Illinois, where he has been continuously, except for two years during the war, first as an undergraduate teacher and later as a graduate teacher and as research professor of structural engineering. Professor Wilson is the author of a number of bulletins of the University of Illinois Engineering Experiment Station, and was awarded the Chanute Medal by the Western Society of Engineers for a paper published in the journal of that Society in 1915, entitled "Wind Stresses in the Steel Frames of Office Buildings." He is chairman of the Examining Committee for Registering Structural Engineers in the State of Illinois and was recently invited to serve on an advisory committee to the Building Code Correlating Committee being organized under the American Standards Association. He is a member of a number of American and European engineering societies and is an active member of many of their committees. He is also a member of the Executive Committee of the Structural Division of the Society and is president of the Central Illinois Section of the Society.

New Elections to Honorary Membership

ALEX DOW

THE BOYHOOD DREAMS of an engineering career must have seemed rather hopeless of fulfilment to Alex Dow when, as a lad of 12, he left his Scottish elementary school to go to work as a clerk. The following eight years of such employment might well have caused them to fade entirely—but such was not the case. At 20 he came to America, still bent upon his purpose. And though he never attended school again, he now holds the honorary degree of doctor of engineering from the University of Michigan, and a few years ago he was described as "the dean of the operating executives in the utility field who arose out of an engineering background."

ALEX DOW

Dr. Dow's first employment in this country was with the Baltimore and Ohio Railroad; from that beginning he swung soon into electrical work, and from then on his rise was rapid. At 27 he was district engineer in charge of the Brush Electric Company's Chicago office; at 30 he was in charge of the construction and design for the lighting of Chicago's south park system. This work earned him such a reputation that the following year he was engaged as municipal engineer to design and build a lighting plant for Detroit. After a period in municipal service he resigned to become vice-president and general manager of the Edison Illuminating Company of Detroit and president of the Edison Sault Electric Company. Later the Detroit Edison Company took over the earlier organization, and in 1912 Dr. Dow became its president, a position he has retained continuously to date.

To his work as operating executive Dr. Dow brings a happy combination of engineering skill and financial sagacity. He has not waited for equipment manufacturers to invent improvements; he has seen to it that his own engineers lead the procession. For example, the first really large boilers used in the United States were installed at one of the Detroit Edison plants; they were designed to Dr. Dow's specifications, and are now known as the Stirling Type-W boiler. Again, Dr. Dow directed the design and construction of the Conners Creek Power House in Detroit, where the first large horizontal turbo-generator, a type that ten years later became almost standard, was installed.

He also is credited with taking the first step in the development of automatic substations; with contributing to the development of differential generators for constant and full load; with originating the system of paired feeders that is now standard; and with being the first to use a high-tension ring transmission line around a large load center. He has encouraged research in a number of fields; for example, the Cottrell system of ash precipitation from smoke was first successfully applied in Detroit to boilers using pulverized coal. His plants have been noted for the adoption of advances in the art of thermodynamics.

Dr. Dow is a safe and sane, far-seeing business man. He believes firmly in providing an adequate depreciation reserve—out of surplus, if need be—and he has stuck to that policy through thick and thin. In 1933 he was proud to state that the Detroit Edison "is an independent outfit... not controlled by any alien interests." He is not one, however, to condemn holding companies as useless or necessarily evil. Many of them would have done well to heed his comment in 1925: "The position of the holding company today is getting to require a very exact definition and a very exact observance of not merely the law but the ethics." Those that had restricted their dealings to the receiving of a reasonable return on money invested, and to the repayment to them for specified services actually rendered, he said, "are going to be in a happy position of not being subject to challenge." Other less ethical concerns "are going to be required to go into details and give a trustee's accounting."

To the art of rate-making Dr. Dow has made many valuable contributions, among which may be mentioned the "active room" method of approximating demand for a residence lighting rate. He was long the head of the rate research committee of the old National Electric Light Association.

For a number of years, Dr. Dow served Detroit as engineer member of the board of water commissioners. During 1927 and 1928, as president of the board, he directed the design and construction of the Springwells station, a project that includes pumping, power, and filtration plants, and cost approximately $24,000,000.

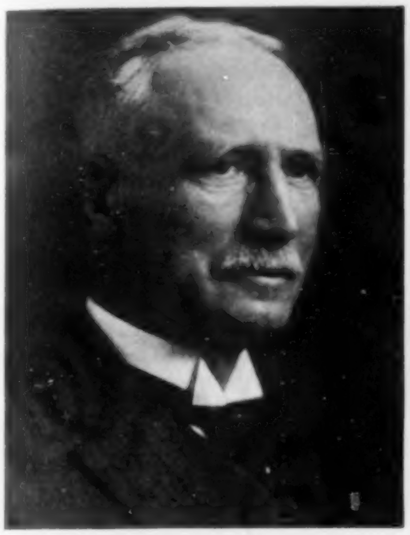
Those who come in contact with Dr. Dow are repeatedly surprised by the multitude of facts he has stored away from his omni-

vorous reading. He speaks fluently, and with what someone has described as "a delicate, disarming sense of humor." His exposition is convincing, and in debate he is vigorous and adept at repartee—yet always gracious.

Although lacking in formal technical training himself, Dr. Dow is keenly interested in engineering education, and for many years he has given fellowships in various engineering fields, particularly in highway engineering, at the University of Michigan. He is a founder of the Detroit Engineering Society, a former president of the American Society of Mechanical Engineers and of the Association of Edison Illuminating Companies; a fellow of the American Institute of Electrical Engineers, and a member of other technical organizations as well. He became a member of the American Society of Civil Engineers in 1906.

GEORGE HERRICK DUGGAN

In 1896 a Canadian yacht "upset the dope" and captured a coveted international award, the Seawanhaka cup. The mayor and aldermen of Montreal turned out to give a public demonstration for its skipper on his return. But that modest sportsman, shunning public acclaim, gave them the slip, alighted from his train at a suburban station, and made his way quietly to his office desk. With similar modesty, George Herrick Duggan has carried all his honors, not only in the realm of sport but in that of intellectual and business achievement.



George Herrick Duggan

A native of Toronto, Canada, Dr. Duggan graduated from the University of Toronto in 1883. His first engineering work was with the Canadian Pacific Railway with which he served an intensive apprenticeship on location, general construction, and bridge work during the early days of that organization. In 1888 he became resident engineer at Lachine, Que., for the Dominion Bridge Company, and while still less than thirty years of age he was appointed that company's chief engineer. In the first decade of the present century he was in the employ of the Dominion Iron and Steel Company and the Dominion Coal Company, and for six years was vice-president and general manager of the latter organization. He later returned to the Dominion Bridge Company, and became its president in 1918. He has recently relinquished that office, as well as the presidency of the Dominion Engineering Works, to become chairman of the board of both companies.

Dr. Duggan has taken a leading part in the construction of many outstanding works in Canada, among which may be mentioned the Interprovincial Bridge at Ottawa, the Montreal Harbor Bridge, and—most notable of all—the Quebec Bridge. Of the latter he was chief engineer throughout the whole period of design and construction. As co-author of a paper describing this structure, he was later awarded the Gzowski medal of the Engineering Institute of Canada.

In addition to his activities in the realm of engineering, Dr. Duggan has been chairman of the Quebec division of the Canadian Manufacturers' Association. He is vice-president of the Royal Bank of Canada, and a director of the Montreal Trust Company and other important financial and industrial organizations, including the Steel Company of Canada, the Dominion Steel and Coal Corporation, and the Shawinigan Water and Power Company.

And he is an Indian chief! The Dominion Bridge Company has for many years employed on its erecting forces a large number of Iroquois Indians from the village of Caughnawaga, just across the St. Lawrence from Lachine. In 1930 Chief Red Eagle, as a token of the appreciation of the Caughnawaga tribe, conferred upon him the title of Chief Ioristorinon—in English, "Strong Iron," a most apt title for a builder of famous bridges.

Dr. Duggan became a member of the Society in 1895. He is a former president of the Engineering Institute of Canada, a former vice-president of the Canadian Institute of Mining and Metallurgy, and a member of the Institution of Civil Engineers of Great Britain, of which he was for a term a member of council and chairman of the Canadian advisory board. He holds honorary degrees of doctor of science from the University of Toronto and doctor of laws from McGill University of Montreal and Queen's University of Kingston, Ontario. In 1931 he received the highest award of distinction of the Engineering Institute of Canada—the Sir John Kennedy medal. He himself recently contributed to the encouragement of the pursuit of engineering knowledge by establishing the Duggan medal and prize, which is administered by the same organization.

His interest in yachting has already been noted, and at least one other adventure in this connection deserves mention. In one of his earlier racing experiences a sudden squall upset and disabled nearly all the boats in the race. By good seamanship Dr. Duggan was able to go to the assistance of others, and for his gallant action he was in 1893 awarded the Royal Humane Society's medal for the saving of life. He is an accomplished yacht designer, as well as a sailor. The boat that he and his friend F. P. Shearwood, M. Am. Soc. C.E., sailed to victory in 1896 was the product of his own experiments. He was one of the founders of the Toronto Yacht Club, the Royal St. Lawrence Yacht Club, and the Royal Cape Breton Yacht Club, and in all these he has held important office.

At present he considers the *Kingarvie*, a trim 65-ft ketch, as his summer home, and to the many friends he entertains on week-end cruises he is affectionately known as "The Skipper."

ROBERT HOFFMANN

To become the outstanding engineer of a metropolitan community is no small honor; and to accomplish this as Robert Hoffmann has done, so thoroughly and yet so quietly and harmoniously, is a rare feat. His career may be epitomized as a lifetime of effort and achievement in the service of his native city. In 1893, he entered the engineering department of the city of Cleveland, and progressed through successive promotions until, in 1907, he was appointed commissioner and chief engineer of the Division of Engineering and Construction. Since 1930 he has served as consulting engineer.

Robert Hoffmann

Robert Hoffmann was born in Cleveland on December 16, 1865. He attended the local schools and then went to Hiram College, from which he graduated in 1885. Later he studied civil engineering at the Case School of Applied Science, graduating in 1893. He has the degrees of Ph.B. and M.S. from Hiram and B.S. and C.E. from Case, and the latter school in 1930 conferred on him the honorary degree of doctor of engineering for "invaluable service to the community." In 1926, the Cleveland chamber of commerce awarded to Dr. Hoffmann the rare "Cleveland Medal for Public Service." The citation in this award read:

"Undisturbed and uninfluenced by partisan considerations or changes of administration, he has steadily pursued a high policy of intelligent, loyal, and effective public service and has both won

the confidence of the people and contributed to the physical reconstruction of Cleveland. . . ."

During Dr. Hoffmann's period of service, Cleveland has increased from a city of 300,000 to its present population of 1,000,000. This growth, coupled with the still more rapid growth of suburbs, has entailed engineering problems of moment and scope—the planning and paving of thoroughfares, bridging of the many valleys, a complex drainage system, readjustment of city facilities to accord with the Cleveland Terminal development, and problems of like nature. All this has called for courageous vision and for understanding of the requirements of financing.

Characteristic of Dr. Hoffmann's professional work has been the setting up of major long-time objectives that have undoubtedly saved the city from confusion and enormous expense during its rapid growth. Once those objectives have been determined, Dr. Hoffmann has seen to it that progressive and unrelenting advancement is made towards their accomplishment. For example, the sewage treatment program represents a step-by-step development over 25 years, at a cost of some $25,000,000. The well-known Tayler grant also reflects Dr. Hoffmann's work in the evaluation of the Cleveland Railway system.

Behind his professional attainments is the man himself. The man in this case is quiet and unassuming, even retiring, but with keen perceptions and a deep knowledge of men. Judicially minded, he believes that even the small tasks merit the care and thought which he gives to all his undertakings. In discussion he is wont to assume the rôle of enquirer and critic, giving scant clue to his own feelings, but when the facts are in, he acts with a directness that goes to the heart of the matter. Fairness that is dispassionate and unheeding of the superfluous, dominates all he does. The best token of this was his appointment by a U. S. District Court, with the consent of all concerned, to serve as master in important litigation to which the city of Cleveland was party. In other instances, recognition of this keen sense of justice has made possible the settlement of differences without recourse to law.

Dr. Hoffmann's very real devotion to his work operates to mask his private life which, characteristically quiet, is none the less rich in zest and appreciation. He has a deep feeling for nature, whether he finds it in his own garden or in driving about the countryside. Recreation he finds in the Professional Club, a variegated lecture and discussion group of Cleveland. Symphony music is also a delight to him.

Any true picture of Robert Hoffmann must portray the essential simplicity and genuine friendliness of the man, his true consideration of others, his rare courtesy, and his humor so quiet and pithy that it may escape notice unless one observes the twinkling eye. Among those of his own organization he is known affectionately as "The Chief," ever open to the need of the individual or the group.

Robert Hoffmann became an Associate Member of the Society in 1901 and was elected Member in 1904. He served as Director from 1932 to 1934. He is a former president of the Cleveland Section and a former director and president of the Cleveland Engineering Society, which also made him an honorary member in recognition of distinguished service. He is a member of the Board of Trustees of Hiram College and of the Corporation of Case School of Applied Science. He holds membership in many technical and civic organizations.

JOSEPH BARLOW LIPPINCOTT

IN A VERY literal sense, Joseph Barlow Lippincott is now enjoying the fruits of his labors. For the orange groves of that twentieth century country gentlemen are his special delight, and his own groves and those of many of his neighbors throughout California spring from land that he himself has reclaimed from the desert.

It was almost half a century ago that Mr. Lippincott went to California as hydrographer and topographer for the U. S. Geological Survey. Since then he has made Los Angeles his home. Through his interest in public affairs, no less than through his engineering services and advice, he has contributed in no small degree to the development and growth of his city and state.

Until 1906 Mr. Lippincott was connected with irrigation work throughout the Southwest, serving in the latter years of the period as supervising engineer for the Pacific Coast District of the U. S. Reclamation Service. In 1906 he was made assistant chief engineer of the construction of the Los Angeles aqueduct. That project was begun when the population of Los Angeles was but 100,000, and it ranks as one of the boldest engineering works ever undertaken by a city of that size—the aqueduct is 250 miles in length and cost $25,000,000. Its success is exemplified by the phenomenal growth of the city that followed its completion.

In 1913 Mr. Lippincott opened offices in Los Angeles as a consulting engineer, specializing in water supply and irrigation projects. Since that time he has been actively engaged in hydraulic problems throughout the western United States, Alaska, Mexico, and the Hawaiian Islands. He has served many of the cities of the Southwest and numerous large irrigation projects both public and private.

JOSEPH BARLOW LIPPINCOTT

Mr. Lippincott is one of those rare persons who can brush aside details quickly to get to the essential facts of a complicated problem. In this connection his friends tell the story of an interview with President Theodore Roosevelt which he once helped to obtain for a lawyer. On their way to the conference, Mr. Lippincott was perturbed to find that the lawyer, although loaded down with legal briefs and engineering reports, had neglected to make a concise summary of his requests. On the back of a calling card, Mr. Lippincott quickly jotted them down. The President's first words to the lawyer were a brisk inquiry as to what he wanted. While the lawyer hesitated, Mr. Lippincott placed the card before the President and said, "Just that." The interview was over a few minutes later; the requests had been granted; and the lawyer's briefs were still in his case.

But although Mr. Lippincott may be concise in presenting facts, he is always willing to go into the greatest detail in determining them. He is always ready to listen to the arguments of all parties to a dispute, and many a conference that seemed doomed to end in disappointment has been saved by his tactful suggestions.

In civic affairs he has given freely of his time. From 1910 to 1917 he was a park commissioner in the city of Los Angeles, which he also served as Civil Service Commissioner. For the past 12 years he has been a member of the water and power committee of the Los Angeles chamber of commerce. His work on these civic boards has been entered into with the same spirit of energy and desire for accomplishment that has characterized his engineering engagements. He has had the moral courage to fight for what he believed to be right; and at times it has not been pleasant or easy.

He has overlooked no opportunity to aid younger engineers. There is always a kindly word of approbation for a job well done, and many instances could be cited of an unsolicited recommendation from him that has led to the advancement of some young man.

Mr. Lippincott's principal interest aside from engineering is his farming operations; one of his greatest ambitions is to raise the best oranges in California, and he is not far from his goal. He has also found time to enjoy the more cultural pursuits. He is a constant reader, particularly of history and biography, of which he has collected a splendid library. He enjoys travel, and has made numerous extended trips to Europe and the Orient.

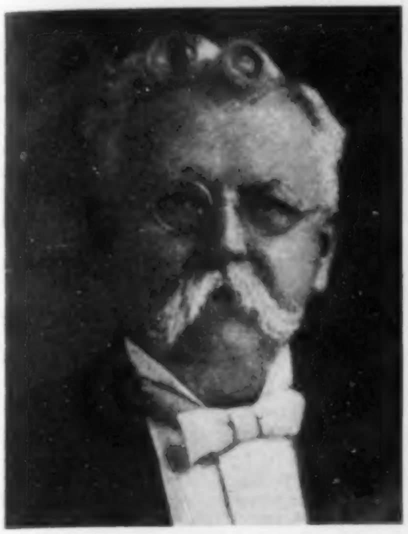
In 1889, Mr. Lippincott was elected to membership in the Society and he has taken an active interest in Society affairs. He had much to do with the organization of the Los Angeles Section in 1914, and was its first president. He has served on many committees of the Society, including the executive committee of the Irrigation Division, of which he was chairman in 1929. He has contributed many papers and discussions, and in 1914 was awarded the J. James R. Croes Medal for his paper on

"Tufa Cement as Manufactured and Used on the Los Angeles Aqueduct." He has also contributed liberally to the general engineering press, and is the author of several of the Water Supply Papers published by the U. S. Geological Survey.

Withal he is a delightful companion, with a keen sense of humor and a large fund of good stories gathered from his experiences. He and Mrs. Lippincott are charming hosts and take great pleasure in entertaining their many friends at their home in Los Angeles or at their ranches in the nearby San Fernando Valley.

JOHN ALEXANDER LOW WADDELL

To see J. A. L. Waddell today, with his robust constitution and active mind, it is difficult to believe that as a boy he was in poor health. As a lad of 16, he was sent to China on a clipper ship to recuperate. The cure was successful; as a mature man he has been strong and vigorous, and able to withstand the rigors of field work regardless of temperature and weather.



John Alexander Low Waddell

In 1889 Dr. Waddell originated the modern vertical-lift bridge, of which he has since designed more than 90 spans. During the succeeding years, he has earned a reputation as a genius in the art of bridge building, and is considered one of the outstanding international engineers in this field. Bridges designed and constructed under his supervision include projects in 25 important cities in the United States and Canada, numerous railway bridges throughout North America, and spans in Cuba, Japan, China, Russia, and New Zealand.

In fact, Dr. Waddell is as well known in the Far East as in America. Some years after his first trip to the Orient he was for four years professor of civil engineering at the Imperial University of Japan. Intermittently thereafter he was called to design bridges in many parts of Asia. In 1921 he had the distinction of being retained by the Chinese Government as the American representative in an international jury of award governing the petition for the new Yellow River bridge for the Peking-Hankow railway. He was also retained to estimate some \$20,000,000 worth of bridges. Again, in 1929, he became technical adviser and construction engineer to the minister of railways of the national government of China (Nanking).

The keynote of Dr. Waddell's professional work can be summed up in one word—economics. In all his writings, addresses, designs, and construction work, this central idea permeates the entire thought. He has never tolerated waste of time, material, or construction. On the other hand, he has never lost sight of the necessity of making all work adequate in every respect for the purpose required. His most outstanding contribution to the economic phase of engineering was his book on the *Economics of Bridgework;* but his *Bridge Engineering* is built around the same center.

Many of Dr. Waddell's scientific writings have been published by the Society. Among them should be mentioned three papers on various phases of bridge engineering that won for him the Norman Medal in three different years. Attention should also be called to his work as a member of a committee of the American Association of Engineers in compiling an extensive book on "Vocational Guidance in Engineering Lines."

Even the busiest men love to play, and Dr. Waddell plays as hard as he works. During his younger days he was fond of hunting big game, and for the past forty years his chief recreation has been deep sea fishing. Each year he makes extensive trips to Florida, Texas, or the Bahamas in quest of kingfish, shark, giant ray, or tarpon, the king of them all. At various times he has held records for catching the largest fish of certain kinds, and for the greatest total catch in a single day or week.

He has also taken a great interest in games of the whist family. Starting with the original game of whist (he was once president of the Kansas City Whist Club) he has kept abreast of the modern improvements—auction bridge and contract—and today plays an excellent game of the latter. Bridge, however, has not interfered with his conversational powers. He has at his command an inexhaustible fund of stories that make him a welcome addition to any gathering, and he carefully adjusts them to the interests of the particular group.

Dr. Waddell's personal characteristics have made it possible for him not only to achieve technical successes but to contribute many intangible benefits to those who have come in contact with him. He has a kindly, human consideration for young engineers and students. He has taken them into his office and given them assistance, and he has helped many students with loans, talks, and valuable counsel.

That numerous honors have come to such a person from all over the world is hardly to be wondered at. His eminent services have been sought far and wide. He is honorary or corresponding member of many foreign societies, including l'Institut de France (Académie des Sciences) and la Academia Real de Ciencias y Artes de Barcelona. He is a Knight Commander of the Rising Sun (Japan); Knight First Class Order of the Société de Bienfaisance of the Grand Duchess Olga of Russia (for services as principal engineer of the Trans-Alaska Siberian Railway project); the Second Class Order of the Sacred Treasure of Japan; the Second Class Order of Chia Ho (China); and the Cavaliere of the Crown of Italy.

To the degree of civil engineer, which he received on graduation from Rensselaer Polytechnic Institute in 1875, have been added the degrees of D.Sc. from McGill University, LL.D. from the University of Missouri, and doctor of engineering from the University of Nebraska and the Imperial University of Japan. In engineering circles, he belongs to most of the prominent professional bodies, and was a charter member of three of them—the American Institute of Consulting Engineers, the American Society for Testing Materials, and the Society for the Promotion of Engineering Education. He became a member of the American Society of Civil Engineers in 1881.

Student Conference to Be Part of Annual Meeting

A Student Chapter Conference has been scheduled for the time of the Annual Meeting of the Society in New York, N.Y. The entire fifth floor of the Engineering Societies Building has been reserved, beginning at 3:00 p.m., Wednesday, January 20, 1937. Invitations to participate have been sent to all the Student Chapters in the country.

The Committee on Student Chapters assigned this conference to the Conference of Metropolitan Student Chapters, whose officers and committees will conduct the affair. A well-balanced program has been prepared in which the principal feature is a round-table discussion of the function of a Student Chapter on a university campus and how its activities differ from those of college social clubs.

In addition, there will be a brief address by the incoming President of the Society, an address by E. M. Hastings, M. Am. Soc. C.E., member of the Committee on Student Chapters, and two short papers prepared and presented by students, with opportunity for discussion from the floor. The conference will be followed by a collation and smoker arranged especially for members of Student Chapters. In spite of the prevalence of term examinations at that time, it is expected that representatives from more than 25 Chapters will be present and that the attendance will total several hundred.

Members of the Society as well as members of all Chapters are cordially invited to attend the student conference on Wednesday afternoon.

The Engineer of Today and Tomorrow

Excerpts from an Address on the Engineer's Responsibility for Solution of Social and Economic Problems

By C. F. HIRSHFELD

CHIEF RESEARCH ENGINEER, DETROIT EDISON COMPANY; FORMER CHAIRMAN, ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

In early times the engineer was probably engaged chiefly in the invention of tools to assist the rather weak human animal in his struggle for existence. Later the energy of the engineer was directed largely to the design, construction, and operation of engines of war. Such occupation is unfortunately far from obsolete. But since the period of the Renaissance his attention has been turned increasingly toward civil pursuits, and within the past fifty years by his technical skill the engineer has produced inventions and materialistic works in such profusion that he has not felt the proper responsibility for solving or offering to assist in solving any of the concurrent social or economic problems. The following article, which is made up of excerpts from Dr. Hirshfeld's address of April 15, 1936, before the Engineers' Club of Birmingham, presents some food for serious thought along these lines. The article also includes a description of some of the activities of the Engineers' Council for Professional Development, a conference of engineering organizations for determining ways in which the professional stature of engineers in all the principal fields may be developed, and engineering in its broadest sense may be advanced.

WE ARE quite accustomed to the inventions the engineer makes; for want of a better name I am going to call them materialistic inventions. Ever since the human world began there has been another line of invention, which I shall call the socialistic type. . . . The engineer has already done a perfectly marvelous job of making materialistic inventions. His contributions of tools and of organization for their use have been the means by which man has extended himself in many respects. He has extended his puny strength, the length of his arm, and the reach of his voice.

But all of the time during which the engineer has been doing these things he has been creating social and economic problems of new types and of real significance. Few persons have addressed themselves properly to the solution of these problems. We are now arriving at the point in our cultural development, however, where we realize that these problems must be solved if the works of the engineer are to succeed in producing the greater and better civilization that we believe is attainable. As an example of the need for comprehensive study and appraisal of such problems, I might cite what is now known as technological unemployment. If you will look back in English history you will discover that every time any device was produced for making things mechanically instead of entirely by hand, some argued against it because of the resultant technological unemployment. But the human race has survived these periods of threatened technological unemployment and each time has lived to pass on to better living conditions as a result of mechanical inventions.

If you will examine census figures you will discover that before the present depression a larger proportion of the total population was gainfully employed in the United States than in 1890. Moreover, between 1890 and 1930 there was a marked swing from agriculture to urban residence and occupations. These facts do not spell technological unemployment to me. I could give other examples that have been cited as accusations against the engineer and show you that each of them falls down upon careful analysis.

SOCIAL RESPONSIBILITY INVOLVED IN ENGINEERING WORK

However, I say to you in all sincerity that I think the engineer has ignored a very important responsibility and still continues to do so. In a very short period of time the engineer has turned our civilization upside down, but he has not thought it incumbent upon him to offer to solve or assist in solving any of the problems which his works have introduced. . . . I do not believe he can longer maintain this attitude. I feel we are heading for some terribly difficult experiences if the engineer does not now begin to interpret to his fellow creatures the real meaning of his works.

How many engineers, for example, have taken the trouble to check up on this question of technological unemployment? Aren't we the people, as engineers, who should be preaching from the housetops the real meaning of our works? . . . I have tried to do it in a small way. So have a few other individuals. But the job ahead is big enough to engage the attention of all engineers. To my mind, the interpretation of our work in its social and economic connotations is now a lot more important than the making of further materialistic or technological developments.

One of the outstanding characteristics of the engineer is that his thinking is factual. When the engineer attacks a problem in his line, he reasons as follows: "What are the facts?" "Where do they lead by a logical process of reasoning?" He does not want to make estimates or assumptions until he is absolutely driven to it. When he is, he makes assumptions knowingly and he says to himself, "That assumption will mean a possible error of plus or minus so much in my final result." And when he gets his answer, he says, "That answer is not necessarily correct; it may be in error by plus or minus so much." Where is there anybody else in our population, other than the scientist, who works in that way? I know of none. As an opposite case, the minister of the gospel works largely upon a set of written words which have been passed down from father to son. The lawyer works in much the same way, except that the written words are amended from time to time by the courts. Both are dependent on precedent.

You have heard the doctors use Latin terms, and lawyers use Latin terms, and you probably have wondered why under the sun they didn't speak in English. Our engineering language to the common run of humanity is just as mysterious as the Latin used by the doctor or the lawyer.

Let me try to give you a simple example. . . . If a man comes to you with a scheme for perpetual motion, you say to him, "That is perpetual motion. That cannot be." That is the end of your argument. To you it is quite sufficient. He does not recognize the situation at all as you do. He believes that perhaps perpetual motion can be. How do you go about explaining to him your reason? Do you realize that you have to take him back to the very fundamentals of science that he does not know in order to explain? I could cite other examples. You just naturally start thinking and talking in a way very different from that used by the much larger part of the human family.

THE ENGINEER SHOULD INTERPRET HIS WORK

The time has come when engineers must learn to talk the language of their fellow beings, other than engineers, so that we can talk to them in words that they can understand. The time has come when we must make it our business to find ways and means of explaining to the masses the real significance of our works. The time has come when we must begin to educate ourselves to the ability to think about the non-technical problems faced by humanity.

Assume that we learn to speak the language of the other fellow and that we prepare ourselves properly for the interpretation of our own works and for the study of social and economic problems. What are we to do then? I am certain that we should not start out to solve all the problems of the universe. We shall still be engineers and very few engineers are going to be successful politicians, lawyers, or spellbinders. But we can be very useful if we will only prepare ourselves along the lines just indicated. We can learn gradually how to interpret our works in terms of economic and social significance, and I think we shall soon discover that, if we will only give our fellow citizens the rights and wrongs of such questions, they will accept them from us because they recognize us as individuals who tell the truth.

Have you ever heard any responsible person question the probable performance of a work of engineering? When the engineer undertakes to put a bridge across a river, the public does not doubt a successful outcome. The newspapers do not question whether the engineer can do it. Can you point out any other

proposal that is made that is accepted in that way, except religious matters that are accepted on faith? For that very reason, when we do explain to the public the real significance of our works I expect that the public is going to believe us.

When our fellow man begins to understand a real problem he generally thinks and acts correctly. Determine what the facts are, then preach them among your fellows, not for political purposes but to produce a greater understanding of the conditions under which we live, and in the hope that by such means we may more concertedly and certainly drive toward a greater and better end.

E.C.P.D. Stimulates Social Consciousness

For some time a few of us have thought that the time was right for the engineer to study social and economic problems as *part* of his work, not *instead* of his present work. As an entering wedge we organized what is known as the Engineers' Council for Professional Development. It is a small beginning, but it has two very definite and I think worth-while objectives—one, to constitute a single organization through which the engineers of this country may cooperate successfully, and the other to build up that kind of engineer who is prepared, who is capable of undertaking the kind of work the engineer in the future must do in addition to the kind of work he has done in the past.

This Council has a membership of seven bodies. Five of them are technical engineering societies: The American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Institute of Chemical Engineers. One of the remainder is the Society for the Promotion of Engineering Education, and the seventh is the National Council of State Boards of Engineering Examiners. . . .

The Council now has four active working committees as follows. The first is known as the Committee on Student Selection and Guidance. It attempts to devise ways and means of helping boys who think they want to study engineering. It undertakes to provide means of showing them what engineering really is, to help them determine whether they can profit from an engineering education, and to help them in the selection of a course and a college.

The second committee is known as the Committee on Engineering Schools. It does not attempt to tell teachers of engineering how to teach engineering. It realizes that the teaching of engineering is in a continuous state of flux. It hopes that by bringing together prominent and thinking industrial leaders, practicing engineers, and educators it may assist in developing better engineering courses, better methods of teaching engineering, and, ultimately, better engineers. This committee also deals with the accrediting of schools of engineering. . . .

Assisting in the Development of Young Engineers

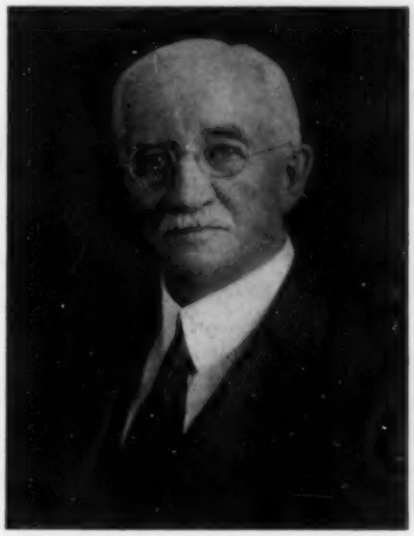
The third committee, known as the Committee on Professional Training, deals with the education of an engineering graduate from the time he leaves school until he measures up as a full-fledged engineer, that is, a man who is competent to practice in his own right. When this time arrives, the man should rate full membership in a major engineering society and should be capable of obtaining a license in any state requiring registration as a prerequisite to practice. The young engineer hopes to rise rapidly and has a tendency to concentrate too narrowly for his own good. We are trying to give his development better balance. We are trying to interest him in literature, philosophy, sociology, economics, general science, and history—in short, to make a balanced individual of him. We hope that when he becomes available for consideration for a minor executive position he will have gone some distance toward becoming a real member of the community. Running parallel with this is the development of men who have not had the advantage of a college education. Realizing that shortly these men will not be allowed to obtain a license unless they can pass a technical examination equivalent to that given college graduates, we have set ourselves the task of assisting these men to obtain the required education.

The fourth committee, known as the Committee on Professional Recognition, concerns itself with those things having to do with the recognition of achievement. It is endeavoring to bring about a general unanimity in what may be called the "minimum definition of an engineer." It hopes that ultimately the state boards, the engineering societies, and others may be able to agree upon that measure of ability and accomplishment required for certain types of recognition.

All this is merely the mechanics of an attempt to produce in the future the kind of engineer that we now realize we should have been. We now recognize some of the limitations under which we work as members of the community in which we live, and we are trying so to arrange matters that the engineers who come after us will not be so handicapped in their communities. To our mind, no man is an engineer unless he has a solid training in the fundamental sciences and in their application to the solution of engineering problems. We are not trying to make a less technical engineer, as some people are trying to do. We are still trying to make real engineers in the old-fashioned sense, but we are trying to make them not only materialistic but human engineers who are willing to take upon their shoulders part of the world's burdens in attempting to solve pressing human problems. They are never going to displace trained men who are already working in the social, economic, and political fields, but I think they are going to become very useful in assisting such workers.

John Fritz Medal Awarded to Arthur Newell Talbot

Arthur Newell Talbot, Past-President and Honorary Member of the Society, has been awarded the 1937 John Fritz Gold Medal, highest of American engineering honors. The citation that accompanied the medal described him as "moulder of men, eminent consultant on engineering projects, leader of research, and outstanding educator in civil engineering." The medal will be presented on Wednesday morning, January 20, 1937, at the opening Session of the Society's Annual Meeting in New York.



Arthur Newell Talbot

The award is made annually for notable scientific or industrial achievement by a board composed of 16 past-presidents of the four Founder Societies. It was established in 1902 by friends of the late John Fritz, Hon. M. Am. Soc. C.E., to perpetuate the memory of his achievements in industrial progress.

Professor Talbot has been engaged in engineering work since 1881, his activities embracing railroads, roads, bridges, buildings, and municipal public works. For more than fifty years he has been a member of the faculty of the University of Illinois. He aided in the upbuilding of the university's testing laboratories and the college of engineering, and has been active in the formation and development of the Illinois Engineering Experiment Station, for which he has made numerous investigations of the properties of steel, brick, concrete, and reinforced concrete, and in water purification, sewage treatment, and hydraulics. As professor emeritus, he still continues his research at the university.

He has also directed studies sponsored by the Society and the American Railway Engineering Association. For outstanding research in railroad-track stresses he was awarded the plaque of the association.

Professor Talbot is the thirty-second to receive the John Fritz award. Among the previous recipients have been such scientists as Lord Kelvin, Edison, Marconi, and Pupin, and six civil engineers—John Ripley Freeman, George W. Goethals, Ralph Modjeski, Alfred Noble, J. Waldo Smith, and John F. Stevens.

Early Presidents of the Society

Various members of the Society have been extremely helpful in supplying illustrative material and biographical data for this series of sketches. The help of still others is earnestly requested for future items. Photographs and personal anecdotes are especially valuable. The next three installments will treat of James Bicheno Francis, Ashbel Welch, and Charles Paine.

X. ALBERT FINK, 1827–1897

President of the Society, 1879–1880

ALBERT FINK was one of those rare engineers who excel equally in design, construction, and management. Early in his career he ranked as the leading bridge engineer of the country, designing the first really long-span iron bridges on this continent and supervising their erection. Later he made a great reputation as a railroad manager during the hectic days of the Civil War. And eventually, through his work in correlating the freight and passenger rates of large groups of railroads, he justly earned for himself the title of "father of railway economics and statistics."

ALBERT FINK, TENTH PRESIDENT OF THE SOCIETY

Fink was born in Lauterbach, Germany, in 1827. His father was an architect, and the son early determined to follow the same profession. He graduated from the polytechnic school at Darmstadt, with high honors, in 1848. But that was the year of the ill-starred German revolution, and like many another young German who had espoused the cause of freedom, Fink soon found it expedient to leave his homeland. He came to America, and took employment under Benjamin Latrobe, chief engineer of the Baltimore and Ohio Railroad, which was then under construction.

It was not long before he became Latrobe's principal assistant and was put in charge of designing and building bridges and other structures for the road between Cumberland and Wheeling. During this time he produced some of his best engineering works, and invented his well-known truss. The first bridge to incorporate that design was the one over the Monongahela at Fairmont, W.Va. It consisted of three spans each 205 ft long, and when completed in 1852 was the longest iron railroad span in the country. It was a through bridge with cast-iron chords and posts and wrought-iron tension rods, pin-connected throughout. The ends of the chords were hung by links on pins in cast-iron towers, and the floor beams were hung by suspension links to the pins connecting the tension rods with the posts—thus allowing all parts of the truss to expand and contract without deranging the structure. Fink's bridge was replaced in 1887, and the present structure is the third at that site.

The Fink truss was a modification of Bollman's, whose assistant Fink was. In those days construction was several steps beyond theory, and both Fink and Bollman, distrusting the rule-of-thumb methods by which many bridges were designed, built intricate models from tin and wire, tested them carefully for stresses and strains, and deduced from their action the formulas for designing the full-size spans. The Fink truss became standard in railroad bridge construction and was used widely until about 1880. Although its inventor held a patent, he apparently made no attempt to commercialize it. The common Fink roof truss of modern practice is a modification of the original design.

In 1857 Fink became assistant engineer of the Louisville and Nashville Railroad. During his spare time in this employment he prepared plans for rebuilding the Louisville courthouse and superintended their execution. In this work he displayed his talent and taste as an architect, and the edifice long ranked as the finest in the city.

Then came the Civil War. By that time Fink was chief engineer, and the years of battle tested his capacities to the utmost. His line ran directly through the region most affected by the contending armies in Kentucky and Tennessee, and was alternately in possession of the Confederate and the Federal forces. The former first seized all but 67 miles of the road, and as they later retreated southward they destroyed many of the bridges, burned the shops, and tore up the track. Fink lost no time in waiting for Federal forces to protect his workmen. He followed up the Confederates with tireless energy, and to the amazement of the military the reconstructions were completed nearly as fast as the Federals advanced, and sometimes ahead of them. So adequate was this work, and the subsequent operation, that the Louisville and Nashville was the only road in the South of which the federal authorities did not take military possession.

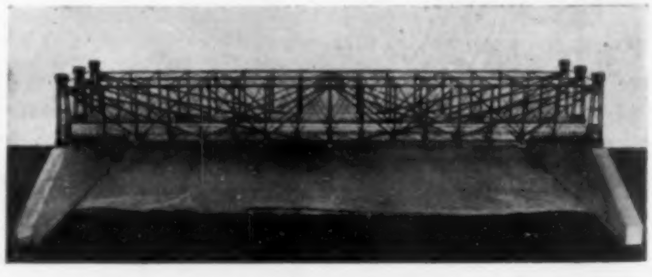
MORGAN'S RAIDERS MAKE TROUBLE

The road was the chief line of communication for the Federals, and carried practically all their supplies. It became an important objective for the Confederates to cripple it, and during the following years it was raided time after time by Morgan and his men—a daring, elusive, mounted band that would sweep in from nowhere capture a train or wreck a bridge, and disappear without trace. But Fink had organized a special corps of bridge builders with which he repaired the damages as soon as the raiders withdrew, and though the enemy's tactics were harassing, they never succeeded in stopping the operation of the road for long.

Amid these vicissitudes he inaugurated and maintained an admirable system of accounts that enabled him to determine the cost of every item of work, and that subsequently attracted so much attention from railroad men. He was made general superintendent in 1865, and with the return of peace he devoted great energies to the reorganization and economical operation of the road. Up to that time railroads had been operated mostly by rule of thumb, and little attention had been paid to the actual cost of the various classes of traffic. Fink raised railroad accounting and statistics to the level of a science, and applied it meticulously in setting the tariffs on his line. The wisdom of his policies, both in financing and in operation, was evidenced in the panic of 1873, when the Louisville and Nashville was one of the few roads in the country that escaped bankruptcy.

Fink's annual reports grew to be bulky affairs, consisting largely of tabular statements from which sound conclusions could be drawn. He was the first to show conclusively by statistics that a branch line, unprofitable in itself, may yield an adequate return when the increased traffic of the main line is taken into account, and he showed so convincingly the unreasonableness of the chronic complaint of some local shippers that their rates were out of proportion to the through tariff, as to put an end to that class of fault-finding for a time.

This work was in the nature of a revelation to other railroad managers and experts, and attracted such general interest that copious extracts from the report of 1873–1874 were reprinted for

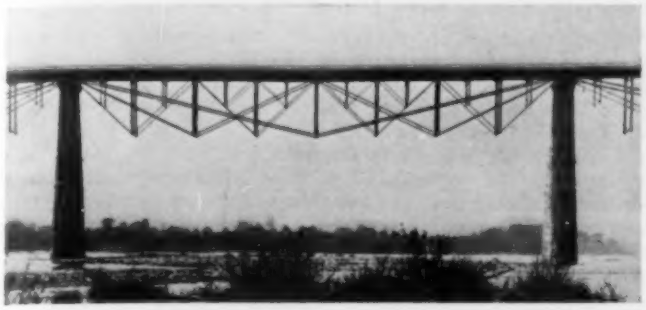


MODEL OF A FINK TRUSS SPAN, THROUGH TYPE, SHOWN AT THE BALTIMORE AND OHIO CENTENARY CELEBRATION IN 1927

The Spans for the Fairmont Bridge Served as the Prototype for This Miniature, Though the Original Was a Single-Track Structure

general circulation under the title of "Cost of Railroad Transportation." This was followed the same year by "Investigation Into the Cost of Passenger Traffic." Modern economists still find the Fink's writings a firm foundation for their work.

In 1875 Fink entered on the duties for which, consciously and unconsciously, he had been preparing for years. A critical period in the history of the railroads of the United States had been reached, and in the decade between 1870 and 1880, a very important change took place in the attitude of those who controlled the properties toward the owners, toward other roads, and toward the public and



Another Major Structure Designed by Fink Was the Bridge Across the Ohio at Louisville, Ky., About 1870

The Span Shown Here Is a Fink Truss, Deck Type, 245 Ft 6 In. in Length

the state. In bringing about this change Mr. Fink did more than any other man.

The stage of expansion had begun to give way to the stage of organization. Unscrupulous railroad officers began to sink in relative numbers and power, and men of high professional spirit became relatively more influential. The theory that railroads are merely private properties began to be supplanted by the theory that they are quasi-public institutions, deriving certain privileges from the state and having corresponding duties to it. The theory of the control of rates and services by competition began to give place to the theory of control by combination.

The Southern Railway and Steamship Association, largely of Fink's creation, was organized in 1875. It was a combination of about 25 southern roads, formed for the purpose of controlling and regulating rates, to the end that they might be kept reasonably permanent and non-discriminatory. The principles on which this organization was founded, and its method of procedure, are said to have had no precedent either in this country or Europe. It was designed as a machine to enable the roads to work together either with or without pooling; it arranged classifications and rates, and served as a clearing house for through-traffic accounts; it saw to it that tariffs were maintained alike to all shippers, without rebates or resort to secret devices. As commissioner and working chief of this organization, Fink was painstakingly thorough. He had frequently to serve as arbitrator to smooth out disputes between the various companies, and won general respect and praise for his justice and tact.

With the association well on its feet, Fink felt that he could withdraw to rest and study. He headed for Europe, but got no further than New York. There, the chief executives of the four eastern trunk lines were endeavoring to work out measures to prevent the recurrence of the disastrous railroad war of 1876. Fink was consulted, and he so greatly impressed the officers that they prevailed upon him to organize and conduct the affairs of their proposed association. The ultimate plan of procedure was devised chiefly by Fink himself. It resulted in the "Trunk Line Association," which included the Baltimore and Ohio, the Pennsylvania, the Erie, and the New York Central and Hudson River railroads. Late in 1878 these lines and their connections agreed to cooperate in all matters relating to competitive traffic, and a "Joint Executive Committee" was formed, with Fink as its chairman. He thus became executive officer, so far as traffic arrangements were concerned, of all the most powerful roads in the country, which controlled transportation in the entire area north of the Ohio and east of the Mississippi.

Of this work he once said: "It is only when rates are maintained, no matter by what means, either by the voluntary action of the railroads or by direct legislative enforcement, that the evils of transportation business complained of by the public can be remedied."

The Interstate Commerce Act of 1887, which initiated the period of government regulation, made work of this type somewhat less vital, and this change, together with Fink's failing health, led him to retire in 1889. He spent the remaining years of his life with his daughter, living at Louisville and traveling extensively. While at home he occupied himself with his books, reading with intense interest works on philosophy and history. Even in his retirement, it is said that when he undertook study he gave all his energy to it. He died suddenly in April 1897.

Fink enjoyed society, but his life was too busy for him often to indulge in social pleasures. His manners were unaffected and very cordial. His tastes were simple, and he spent little for personal use, though he was lavish in giving. Though several of his inventions made the fortunes of other men he himself neglected to exploit them. It was said of him that to be able to do good or relieve suffering was his principal happiness.

Fink became a Member of the Society in 1870, and a Fellow in 1872. He served as Vice-President for two years, and as President from November 5, 1879, to November 3, 1880.

[The courtesy of Philip George Lang, Jr., M. Am. Soc. C.E., in supplying the accompanying illustrations from the records of the Baltimore and Ohio Railroad Company is appreciatively acknowledged. Biographical data on Albert Fink are relatively plentiful. The present sketch consists largely of near-verbatim excerpts from the comprehensive memoir in Transactions, Vol. 51 (1899). A valuable reference prepared in 1927 is "A Bibliographical Memoir of the Father of Railway Economics and Statistics in the United States," Bureau of Railway Economics, Washington, D.C.]

Annual Report Issued by the Engineering Foundation

At the annual meeting of the United Engineering Trustees, held in New York, N.Y., on October 22, 1936, the Engineering Foundation presented a condensed report for the fiscal year ending September 30, 1936. The Foundation's immediate objective is the furtherance of researches by the Founder Societies and other engineering organizations directed toward solutions of problems of benefit to the profession or the public, of technological or human interest, in which engineering methods and knowledge may be utilized.

Among the activities aided by the Foundation of special interest to civil engineers is the research in earths and foundations, continued by the Society during the past year. This included "participation in the International Conference on Soil Mechanics and Foundation Engineering at Harvard Graduate Engineering School, in June 1936, which indicated great expansion since the committee [on Earths and Foundations] began work in 1929. Dr. Terzaghi, of the committee, presided. Field and laboratory research in America and Europe progressed under encouragement of the committee. The committee's support helped in establishing an advanced soil mechanics laboratory at Harvard University. At Yale University support was given to investigation of lateral supporting power of soils to individual piles, anchors, and bulkheads. At Columbia University the equipment and methods of the Barodynamic Research were utilized for a variety of problems. At the University of Minnesota extensive researches were made in the subjects of earth dams and cofferdams with the aid of models."

Following is a summary of the financial resources of the Engineering Foundation:

"Capital Funds

"Endowment, total book value 30 September 1936 .	$870,000
"E. H. McHenry bequest in hands of executors until decease of two life beneficiaries, appraised at probate of will in 1931, approximately	$400,000

"The capital funds are held and administered by United Engineering Trustees, Inc. The net income from endowment was $34,126 for the fiscal year ended 30 September 1936. The Foundation Board has discretion in use of income. For many of

the enterprises which the Foundation has aided, large contributions of money, services, and materials have been obtained from others.

"CURRENT RESOURCES: SUMMARY

"Balance 1 October 1935		$ 31,352
"Receipts:		
Income from endowment and temporary investment of income balance	$34,531	
Income from minor items	764	35,295
Total resources		$ 66,647

"EXPENDITURES: SUMMARY

"Research projects	$36,571	
"Promotion of research and administrative expenses	12,277	
"Total for furtherance and support of research . . .		$ 48,848
"Balance 1 October 1936		$ 17,799

"Money contributions from organizations and individuals, for specific activities, passed through the Foundation's accounts from its organization to 30 September 1936, totaled $249,315."

Members Exempted from Payment of Dues

ON JANUARY 1, 1937, 120 more members of the Society become exempt from the payment of dues. This is in accordance with the constitutional provision applying to those who are 70 years of age and have paid dues as corporate members for 25 years, and to those who, being less than 70, have paid dues for 35 years.

The notification brought, as usual, a large number of interesting replies. One member commented that it was a pleasant change to hear of some compensation for advancing years, and another wrote: "It has been such a pleasure for the past 35 years to be a member that I consider the payment of dues of minor importance. However, since the rule is established, I will take advantage of it."

"To one starting on a term of 35 years," wrote a third, "it seems to be a long time, but when the term has been accomplished, it seems indeed short." Several took occasion to acknowledge the value of membership to them as professional men. One refers to life membership as a life-long ambition, and another confesses that he has received much more from the Society than he has put into it, "not because I've been lazy but because I've led a busy life."

One letter in particular recalled the great change that has taken place in the Society itself since 1900. The writer remarked that his first active interest in Society work was as a member of a local committee in Seattle, "where we were clamoring for recognition from the Board of Direction, which had trouble in seeing over the Allegheny Mountains, to say nothing of the Rockies." Today he finds that the response to that clamoring has become whole-hearted, "and now I believe we have a truly national Society."

The complete list of those newly exempted appears elsewhere on this page.

THESE MEMBERS HAVE EARNED THE RIGHT TO EXEMPTION FROM PAYMENT OF SOCIETY DUES

(Members Exempt Jan. 1, 1937)

Alfred, Frank Hooker
Atkins, Harold Bedford
Auryansen, Frederick
Bacon, George Morgan
Banks, John Edwin
Bennett, William Benjamin
Bernegau, Rudolph Caspar Carl Marie
Binkley, George Holland
Blanchard, Murray
Bogen, Louis Edward
Boyd, Joseph Charles
Brenneke, William George
Byers, Charles Hopkins
Carmalt, Laurance Johnson
Cellarius, Frederick Julius
Clapp, Joseph Malcolm
Collins, Clarke Peleg
Copeland, William Rogers
Corning, Dudley Tibbets
Covell, Vernon Royce
Dakin, Albert Harlow
Davis, Charles Stratton
Davis, Leonard Henry
Derleth, Charles, Jr.
Develin, Richard Griffith
Diehr, Alvah Benjamin
Dillenbeck, Clark
Dufour, Frank Oliver
Eagleson, Ernest George
Eddy, Harrison Prescott
Emery, James Albert
Fay, Edward Bayrd
Fay, Frederic Harold
Fenkell, George Harrison
Finley, Edwin Clifford
Ford, Frederick Luther
Frye, Harley Edgar
Fuller, Almon Homer
Gerig, William
Gessner, Gustavus Adolphus
Gideon, Abraham
Gifford, Lester Robinson
Glazier, William Leonard
Gowen, Sumner
Grossart, Lewis John Henry
Hall, Louis Wells
Hammond, John Farnsworth
Hastings, Frank Arnold
Hatt, William Kendrick
Hazen, William Nelson
Hedges, Samuel Hamilton
Henderson, John Thomas
Hillyer, William Ross
Hirst, Arthur
Hittell, John Benjamin
Hubbard, Winfred Dean
Hughes, Francis Dey
Hyde, Charles Gilman
Jessup, Joseph John
Kadono, Chokiuro
Kutz, Charles Willauer
Lea, Allan Benjamin
Lea, Richard Smith
Lewis, Clarence McKenzie
Liebmann, Alfred
Livermore, Norman Banks
Lovell, Walter Danville
MacCrea, Don Alexander
McCulloh, Ernest
McDonald, William Naylor
Mann, John Laroy
Mitchell, Charles Hamilton
Mott, William Elton
Nethercut, Edgar S.
Newell, Joseph Pettus
Noble, Frederick Charles
Noble, Walter Edwin
Olberg, Charles Real
Parsons, Archibald Livingstone
Pearl, Walter
Pill, John Richards
Pitts, Thomas Dorsey
Pollock, Clarence DuBois
Pope, John Horton
Pulligny, Jean Leclerc de
Race, John Marble
Rickey, James Walter
Riegler, Louis John
Rights, Lewis Daniel
Ruffin, Charles Lorraine
Ruggles, Charles Arner
Sanders, Francis Nicoll
Schneider, Herman
Shearwood, Frederick Perry
Silliman, Charles
Skillin, Edward Simeon
Smith, Chester Wason
Smith, Harradon Sterling
Spofford, Charles Milton
Stearns, Fred Lincoln
Steffens, William Frederick
Stratton, George Eber
Tenney, Willis Robinson
Tilden, Charles Joseph
Tompkins, Edward De Voe
Travell, Warren Bertram
Trout, Charles Eliphalet
Tutwiler, Thomas Henry
Tyler, William Dowlin
Tyrrell, Warren Ayres
Verrill, George Elliot
Vose, Richard Hampton
Vrooman, Morrell
Walker, Joseph Jeanes
Weston, Robert Spurr
Wiggin, Ernest Woodbury
Wiggin, Thomas Hollis
Wilson, Percy Hartshorne
Wolfe, Frank Gordon
Wood, George Pillsbury

Putting the Mail Through the Mill

DURING THE MONTH of December, 75,000 pieces of mail were shot through the addressographs at Society Headquarters. From a mechanical standpoint, of course, this is an easy job—a few days' work for a single operator. But the mechanical work is only a small part of the problem.

Engineers are notoriously nomadic, and keeping up with the peregrinations of some 15,000 of them is no easy task. Every change of address means at least one new stencil for the machine, and perhaps as many as a dozen—for some members are listed in that many distinct classifications. Certain changes of employment also necessitate changing the stencil, even though they do not affect the address. And last but not least, many members have two or more mailing addresses—one for publications, and another for other correspondence. The job of keeping these data up to the minute is nevertheless handled systematically, and usually, that within a day of the receipt of a change of address, every pertinent file card and stencil is revised and checked. This is impossible, however, at the busy time of the year, when two or three hundred changes are received daily.

The master card file is a strictly alphabetical list. The card of each member records his latest address and occupation, special instructions he may have given in regard to mailing, and other pertinent data. It is kept in the file at all times, and is used by the stenographers to check the address on each typewritten communication that leaves the office. A duplicate set of cards is used for a working file. These cards show also the names of the Technical Divisions to which a member belongs.

When a member notifies the Society of a change in address, the master file card is immediately corrected and replaced; the working-file card is also corrected and commences "going the rounds." Daily lists of changes are prepared, checked, and turned over to the operator who cuts the stencils. She also inserts "tabs" on the stencils where necessary. This is done, for example, when a member requests that his publications be held until he has a permanent address, or to indicate those members whose dues are in arrears, and who do not receive publications. The tab causes the machine to skip that stencil automatically.

The total number of stencils on hand at present is about 33,000. One set is arranged alphabetically, under states, by Districts, with the Juniors kept separate from the Corporate Members, so

that ballots for any particular District can easily be mailed to the persons entitled to receive them. There is another alphabetical set for each of the 11 Technical Divisions—and of course some members will have a stencil in each of these sets; many others are represented in at least two. Still other sets of stencils are on hand for Local Section officers, Student Chapter officers and faculty advisers, non-member subscribers to CIVIL ENGINEERING and PROCEEDINGS, and other groups.

Perhaps many members have puzzled over the capital letter appearing just below and to the right of their address on stencil-addressed mail. This symbol is provided for the benefit of the circulation auditors, who must know the general occupation of each subscriber. An "L," for example, indicates that that member is connected in some way with a municipal government organization; "D" that he is with an industrial concern; "B" that he is with a construction company or contractor. Another symbol that may appear on the stencil is a star, indicating that that member receives his TRANSACTIONS in cloth binding, or a number sign, indicating the half-morocco cover.

A competent and well-trained staff sees to it that changes are made promptly, and with a minimum of "boners."

A Junior Attends His First Annual Meeting

And Finds to His Surprise a Warm Welcome from Older and Younger Men

Many a young member has been through experiences similar to those described here relating to the 1936 Meeting; but few have taken the pains of jotting them down, to say nothing of submitting them. While withholding his name, the author has given permission for printing his observations in the hope that other young men will be encouraged to essay his experiment for the forthcoming Annual Meeting, and in the confidence that they will be equally well repaid.

I HAD NEVER been especially interested in attending an Annual Meeting of the Society. New York was always far away; I had the fairly typical idea that the Meeting would be a glorified Metropolitan Section get-together, with austere New Yorkers tolerating or perhaps ignoring the presence of a few visitors from "the provinces." The Technical Sessions, it seemed, would be useless to attend—how much easier and better it would be to wait a month or two and read the papers and discussions as they appeared in CIVIL ENGINEERING, when I would have time to read them at my leisure. Moreover, I am one of the younger men—the oldsters would run the Meeting, I knew, and would have their own unapproachable groups and cliques that a young man might develop an inferiority complex over, if he made an attempt to intrude.

But now I have been to my first Annual Meeting—my first, I hope, of a long succession of such affairs. In view of my experiences and my complete change of attitude I feel I owe it to the Society to make this explanation in the interest of those others who have doubtless been under the same false impressions.

A New York meeting indeed! It did not take long to discover that the common bond of professional interest had drawn men not only from the metropolitan area, not only from the eastern states, but from the deep South, the states beyond the Mississippi—even an admirable and jovial group of Californians who had left their paradise of thoroughly publicized winter weather for a transcontinental trek to the more mundane atmosphere of the east coast.

And these New York engineers! How careless I had been in classing them with that multitude of less trained easterners who look on Ohio as the Far West, on all but residents of the Big City as provincials, and picture an unrelieved treeless and waterless plain extending from the Appalachians to the Pacific! Metropolitans in domicile, perhaps, these engineers—but cosmopolitans in spirit and in acquaintance.

Cliques? Perhaps. But I didn't find them. It was natural, of course, for gray-bearded gentlemen, meeting by chance in the halls, to seek out a quiet corner for a confidential chat—but there was no sudden congealing when younger men and strangers entered the group. I was especially pleased at the luncheon on Wednesday with the seating arrangements—no place cards; no formality. You worked your way through the crowd to a vacant place at table and sat down. The man on your right was an Oregonian; the one on your left from Kentucky. All strangers at the cocktail course—all thoroughly acquainted and slow to break away when the dessert was removed.

As for the technical sessions, I find there is a vast difference between reading the results in a book and listening in the company of many others. A rapid-fire discussion follows each paper—questions that put each speaker on his guard—passing witticisms tying down a point that might otherwise be missed completely. Now at my leisure I can read the CIVIL ENGINEERING abstracts, filling in from memory the personalities that have attached themselves to each.

The final point I think worth mentioning is the variety afforded by the Meeting. It began on Wednesday with a simple and impressive ceremony conferring honorary memberships and prizes. It was a distinct pleasure to be present, and to join even as a spectator in this ceremony for those whom the profession has delighted to honor. The unaffected tributes paid to each and their unostentatious and modest acceptances filled me with pride in my profession and with a hope to uphold its honor to the utmost of my ability.

That evening the formal banquet and ball took place. Here was a symbolism of an important aspect of engineering in its broadest sense, highly suggestive of the part that engineers are increasingly coming to play in our national economy. Quite able to hold their own with bankers, economists, statesmen, or what not. Yet democratic, warm, and pleasant.

On Thursday came the technical sessions, which portrayed the professional life of the engineer. I have said enough about these already, except to add a mention of the student conference that completed for me the first true picture I had had of the Society as a whole—students of engineering, yet to have their first scrap with a mixer foreman or pick out the steel for their first reinforced concrete job, being amalgamated into, and instilled with, the spirit of an organization that is big enough to include such men as Mead, Tuttle, Talbot, Ridgway, and thousands of others.

Vice-Chairman of Engineers' Council, R. I. Rees, Dies

ROBERT IRWIN REES, vice-chairman of the Engineers' Council for Professional Development and assistant vice-president of the American Telephone and Telegraph Company, died in Detroit, Mich., on November 23, 1936. His death was preceded by a sudden collapse just before he was to address an E.C.P.D. luncheon meeting on November 18. General Rees was 65 years old. His home was in New York, N.Y.

Born in Houghton, Mich., General Rees graduated from the Michigan College of Mining and Technology and later attended Harvard University and the New York Law School. He was commissioned a second lieutenant in 1899, and served in the Spanish-American War and the Philippine Insurrection. In 1913 he graduated from the Army School of the Line with special honors. At the outbreak of the World War he was detailed as a member of the general staff corps in Washington, and in January 1918, became chairman of the national committee on education and special training. Sent to France in December 1918, he was assigned to General Pershing's staff with the rank of brigadier general in charge of all educational work in the American Expeditionary Forces. For his war service he was awarded the Distinguished Service Medal and was made an officer of the French Legion of Honor.

After the war, General Rees attended the Army War College, from which he graduated in 1923. In 1924 he became assistant vice-president of the American Telephone and Telegraph Company. He resigned from this position effective December 1, 1936, to devote full time to his duties as vice-chairman of E.C.P.D., which he had served as chairman of the Committee on Professional Training since its inception. He was also chairman of the Council's Committee on Ways and Means. General Rees was a former president of the Society for the Promotion of Engineering Education and a member of the executive committee of the American Association for Adult Education.

Hydraulic Symbols Submitted by Society Committee for Discussion

THE SOCIETY'S Special Committee on Hydraulic Research has tentatively adopted a list of symbols for use primarily in hydraulic laboratories, with emphasis on open-channel work. It is presented here for discussion. In preparing the symbols, great weight was given to usage and published lists ("Letter Symbols and Glossary for Hydraulics, with Special Reference to Irrigation," Manual No. 11, Manuals of Engineering Practice of the Society, October 11, 1935; and American Standards Association, 1929, adopted as a tentative standard by the Association, published in CIVIL ENGINEERING for July, 1934).

Where several symbols for the same item were found to be in common use an alternate symbol was added to the preferred symbol.

Specialized notation suitable for mechanical, mathematical, or hydrodynamic problems was avoided in this list but can easily be developed from it as a basis by using the corresponding Greek letters. Instead of giving the same symbol with a large number of subscripts for special uses, the note, "subscripts for particular" is given to indicate the user's freedom to set up suitable subscripts.

SYMBOLS TENTATIVELY ADOPTED BY THE COMMITTEE FOR USE IN HYDRAULIC LABORATORY PRACTICE

ITEM	PREFERRED SYMBOL	ALTERNATE SYMBOL
Acceleration:		
general	a	
gravity	g	
Area	A	a
Breadth (see width)		
Coefficient:		
general	c	C
of velocity	c_v	C_v
of contraction	c_c	C_c
of discharge	c_q	C_q
(subscripts for particular)		
Coefficient of roughness:		
Kutter and Manning	n	
Bazin	m	
Chezy	C	
Weisbach-Darcy (friction)	f	
Density $\left(\text{mass density } \frac{W}{g}\right)$	ρ (rho)	
Depth:		
general	d	y
Belanger's critical	d_c	y_c
normal (neutral) for uniform flow	d_o	y_o
vertical	y	
(subscripts for particular)		
Diameter	D	d
Discharge	Q	q
Elevation	z	Z
Energy head (energy per unit weight)	e	
specific energy head (referred to channel bed)	ϵ (epsilon)	
Flow (see discharge)		
Force:		
general	F	
tractive	F_t	
Froude number*	**F**	
Head, general (subscripts for particular)	H	h
Height above datum	z	
Hydraulic radius	R	
Length, general	L	l, x
Mass	m	M
Model scale:		

Use subscripts m for model, p for prototype, and r for the ratio of any quantity in the model to the corresponding quantity in the prototype.

Example:

(1) $\frac{Q_m}{Q_p} = Qr = \left(\frac{l_m}{l_p}\right)^{5/2} = l_r^{5/2}$ — alternate: $l_r^{5/2}$

(2) $\frac{Q_p}{Q_m} = \frac{1}{Q_r} = \left(\frac{l_p}{l_m}\right)^{5/2} = \left(\frac{1}{l_r}\right)^{5/2}$ — alternate: $l_i^{5/2}$

(3) $\frac{V_m}{V_p} = \frac{C_m \sqrt{R_m S_m}}{C_p \sqrt{R_p S_p}} = \left[\frac{C\sqrt{RS}}{C\sqrt{RS}}\right]_p^m = [C\sqrt{RS}]_r$

ITEM	PREFERRED SYMBOL	ALTERNATE SYMBOL
Pressure:		
intensity of	p	
total (force)	P	
Quantity (see discharge)		
Reynolds number*	**R**	
Shearing stress (fluid flow)	τ (tau)	
Slope:		
sine of angle with horizontal	S	
of water surface	S_w	s_w
friction	S_f	s_f
of energy line	S_e	s_e
of channel bed = neutral (normal)	S_o	s_o
(subscripts for particular)		
Surface tension	σ (sigma)	
Temperature, general	T	t, θ
Time	t	T
Velocity:		
general	V	v
mean	v	V
components in x, y, z direction	u, v, w	
wave	u	
velocity of approach	v_a	V_a
Belanger's critical	v_c	V_c
Kennedy's critical	v_k	V_k
maximum	v_{max}	V_{max}
(subscripts for particular)		
Viscosity:		
absolute	μ (mu)	
kinematic	ν (nu)	
Volume	V	
Weight:		
total	W	
specific (per unit volume)	w	γ (gamma)
Wetted perimeter	P	p
Width	B	b
channel bed	B_b	b_b
water surface	B_t	b_t
(subscripts for particular)		
Weirs:		
crest height	Z	p
crest length	B	L
degree of submergence	N	

Comments on this list will be appreciated.

SPECIAL COMMITTEE ON HYDRAULIC RESEARCH

J. C. STEVENS, *Chairman*,
1202 Spalding Building,
Portland, Ore.

Members:
C. E. BARDSLEY
E. W. LANE
L. G. STRAUB
H. D. VOGEL
C. A. WRIGHT, *Secretary*

Cooperating members:
H. A. THOMAS
F. T. MAVIS
C. A. MOCKMORE
M. P. O'BRIEN

* Bold face type for printing—underscored for typing.

A Hard-Working President

MANY AN engineering honor requires little more of the recipient than a gracious speech of acceptance. But as Dr. Mead has demonstrated during the past year, the acceptance of an honor may afford opportunity for intensive service even beyond what some would view only as an obligation.

Since the last Annual Meeting, President Mead has traveled to all parts of the country, attending meeting after meeting of Local Sections, Student Chapters, and various national and local organizations. At a conservative estimate, these journeys on Society work account for a travel distance equal to two-thirds the circumference of the globe.

In all he has visited 27 Local Sections, 17 Student Chapters, 6 joint meetings of Sections and Student Chapters, and 9 other assemblies of various nature. All this has been in addition to the meetings of the Board of Direction, and the numerous sessions of the quarterly meetings of the Society. And every visit has meant at least one speech—not a set one, either.

His trips were made in every month of the year but June and September. In January he was as far east as Boston, Mass.; late winter found him in Washington, D.C., and the Middle West; his spring trip carried him through Texas, Tennessee, and back to Washington. After the Annual Convention he made an extensive tour throughout the Far West, visiting Sections along the coast and in the mountain states. In the early fall he was as far south as New Orleans—then spent almost the entire month of November and part of December in various states in the Middle West.

The value to the Society of this generous contribution of time and energy will be felt for many years. It has brought members of Local Sections to a firmer realization of their part in a truly national organization; and it has given students a clear picture of the work of the Society and inspired them with its ideals.

Award of Alfred Noble Prize for 1936

THIS YEAR the Alfred Noble Prize goes to an electrical engineer—Abe Tilles, Assoc. A.I.E.E., for his paper, "Spark Lag of the Sphere Gap," which was published by the Institute in the August 1935 issue of *Electrical Engineering*.

This prize, which was established in 1929, perpetuates the name and achievements of the late Alfred Noble, Past-President of the Society and former president of the Western Society of Engineers. The award is made to a member in any grade of one of the four Founder Societies or of the Western Society of Engineers, for a technical paper of special merit accepted by any of these societies for printing, in whole or in abstract, in any of their technical publications. The author must be not more than thirty years old at the time the paper is accepted in its final form.

The prize consists of $500 and a certificate bearing the signatures of the President and Secretary of the Society, which acts as trustee of the fund. This is the fourth time that the Alfred Noble Prize has been awarded. The first award, made in 1931, went to C. T. Eddy, a mining engineer. In 1932 the recipient was an electrical engineer, Frank M. Starr, and in 1933 the award went to a civil engineer—C. Maxwell Stanley, Jun. Am. Soc. C.E.

Junior Branch Organized in Chicago

JUNIORS OF THE Society living in the Chicago area have organized a Junior Branch under the auspices of the Illinois Section. At a dinner meeting on October 26, 1936, H. A. E. Scheel and Milo S. Ketchum, Jr., were elected chairman and secretary of the group, respectively, and C. L. Waterbury was chosen as junior correspondent for CIVIL ENGINEERING for the Illinois Section. Also a three-month program of activities was mapped out. John L. McConnell, M. Am. Soc. C.E., has been designated by the Section to serve as sponsor.

Bi-weekly meetings are to be held, and frequent Saturday afternoon inspection trips are planned. A committee is now studying the constitutions and by-laws of other Junior Branches, and will present a draft for discussion and adoption early in 1937. Speakers at the first few meetings have included J. G. Bennett, M. Am. Soc. C.E., who urged young engineers to work to gain greater recognition for their profession, and M. A. Gray, Jun. Am. Soc. C.E., who presented and discussed two reels of motion pictures showing the erection of the *U.S.S. Akron*.

Louisiana Engineers to Hold Annual Meeting

THE LOUISIANA Engineering Society will hold its annual meeting on January 22–23, 1937, at New Orleans, La. Providing an opportunity for the various sections and student chapters of the national engineering societies of that state to come together, the two-day meeting will include day and evening sessions and inspection trips. The presentation of papers and general discussion will constitute a forward step towards concerted action by all branches of the profession in securing joint professional aims and recognition. Local sections of the following national organizations will take part: American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Chemical Engineers, American Society of Municipal Engineers, and Society of American Military Engineers.

Army Engineers Entertain New York Student Chapters

ON NOVEMBER 18, 1936, the Student Chapters of Manhattan College and New York University were entertained at a smoker by the commissioned and non-commissioned officers of Company D, 102d Engineers (27th Division, New York National Guard). The company commander, Capt. Charles B. Ferris, Assoc. M. Am. Soc. C.E., made the arrangements and acted as master of ceremonies.

Basketball teams from the membership of the two Chapters played an exciting game on the floor of the armory at 168th Street, in which the score was far less important than the enjoyment of participants and audience. Following the game, the members of the two Chapters, 42 in number, were conducted through the professional school of the regiment, where they inspected models of the types of construction utilized by combat engineers, studied the organization and typical operations of engineer troops, and saw several reels of motion pictures made with the camera which is the property of the company.

Following the demonstrations, the group assembled in the squad room of Company D, where it was addressed by Maj. H. M. Yost, Corps of Engineers, regular army instructor to the regiment. Major Yost, who is an Associate Member of the Society, gave a brief outline of the history of the Corps and stressed its Janus-headed characteristics in that it functions both in peace and in war.

Refreshments were served and opportunity was given group members to ask questions, to get acquainted with the officers and non-commissioned officers, and to become more thoroughly acquainted with one another.

Appointments of Society Representatives

LOUIS C. HILL, M. Am. Soc. C.E., will represent the Society on the Assembly of American Engineering Council for 1937. The other Society representatives on the Assembly are Alonzo J. Hammond and Arthur S. Tuttle, Past-Presidents Am. Soc. C.E.; Daniel W. Mead, President Am. Soc. C.E.; and George T. Seabury, Secretary.

RUDOLPH P. MILLER and MELVIN S. RICH, Members Am. Soc. C.E., will continue to serve as Society representatives on the Building Code Correlating Committee of the American Standards Association.

C. E. MYERS, M. Am. Soc. C.E., has been appointed a Society representative on the Committee on Safe Highways of the American Road Builders' Association.

American Engineering Council

The Washington Embassy for Engineers, the National Representative of a Large Number of National, State, and Local Engineering Societies Located in 40 States

THE BUREAU OF Labor Statistics reported in September that average hourly wages in the building trades had reached the highest figure since July 1933. The average for the three-year period was $0.662, and the lowest monthly average was $0.528 in October 1933. Reports from the PWA offices of all 48 states indicate an average pay on both federal and non-federal programs of $0.776 during September 1936.

The Bureau of Public Roads announced the initiation of a study in November of the causes of highway accidents and conditions contributing to them. It is being made under the Act of Congress in June 1936 authorizing an expenditure of $75,000. The results of the survey are expected to serve as a basis for future safety legislation. State highway departments are reported to have received a total of $902,010,000 for all highway purposes in 1935. Federal allocations amounted to $219,381,000. Thirteen states had transactions exceeding twenty-five millions.

Public Works Administration Notes

The Housing Division of the Public Works Administration reports a continuation of its struggle to effect lower construction costs. In addition to the rejection of bids where they appear to be excessive, it takes time to revise its own plans and in some instances to redesign buildings for slum clearance.

During November, PWA announced the allotment of $2,760,000 to the Imperial Irrigation District of El Centro, Calif., for the construction of the first unit of the All-American Canal power project. The canal was contemplated in the Boulder Canyon Project Act. It will extend 80 miles to tap the Colorado River 15 miles north of Yuma, Ariz. The water-power potentialities include four power sites capable of generating a relatively large amount of electrical energy for the Imperial Valley. Since July 1936, the Public Works Administration had made 1,805 allotments for projects estimated to cost $268,820,909, of which grants are $121,519,435 and loans are $13,894,600.

Resettlement Administration seems most likely to abandon many of its present activities, and there is a possibility that most of them may be transferred to other agencies having permanent status. It is too early to accurately size up the situation, but the submarginal-land purchase program seems certain to go to the Department of the Interior. Land utilization and the rehabilitation of distressed farm owners and tenants may go back to the Department of Agriculture. Farm debt adjustment may be returned to the Farm Credit Administration. Suburban and rural housing is being studied for possibilities of merging it with other housing activities. Mr. Tugwell's sudden resignation and the President's absence leaves the actual future of the Resettlement Administration an open question. Even the transfer of WPA drought cases to it does not indicate extension of life.

Facts About Social Security

The Social Security Board has extended its compliance date to December 15, 1936. According to present information, all employers should notify employees before January 1, 1937, that 1 per cent of wages and salaries will be deducted for federal old-age benefits. This is in addition to deductions now being made in some states for unemployment insurance. Employees should use the name by which they are known on their employer's pay roll.

The Post Office Department has been charged with the responsibility of making a canvass of all employers who are delinquent in returning "Employer's Application for Identification Number," Form No. SS-4. Only one identification number will be issued to a business concern or corporation, and only one tax return need be filed even though each office, factory, warehouse, store, station, or branch has been asked to fill out the form.

A return must eventually be made by every business establishment except educational and eleemosynary institutions, unless there is a change in the law or its interpretation. Employers or employees in doubt as to whether they come within the scope of the Act should either fill out an application form and return in the required way or seek advice from the local postal authorities.

Inauguration of old age benefit requires cooperative compliance until at least three forms are complete. Form No. SS-4, or the employer's application for identification number should come first; Form No. SS-5 or the employee's application for his or her account number should come next; and then the employees' account cards should be completed by the employees' signature. Old age benefits will be based directly on wages earned in this country up to the time the worker is 65 years of age.

Grants totaling several hundred thousand dollars have already been made to the states under the terms of the Social Security Act by the federal government to pay the costs of administering state unemployment compensation laws. Such laws must first be approved by the Social Security Board and must set up administrative machinery to give workers their full rights under the law. All applicants for positions with the board must have a Civil Service status. The basic staff has been complete, however, for some time. In fact, there are some 4,000 employees. Of them, 2,000 are in Baltimore, 1,500 in Washington, and about 500 in the 68 field offices.

The U. S. Treasury Department, by authority of the President and through Secretary Morgenthau, has announced another important step in the direction of international monetary equilibrium. Arrangements have been made for Belgium, the Netherlands, and Switzerland to cooperate with the United States, Great Britain, and France in accordance with the principles of the tripartite declaration of monetary stabilization on September 25, 1936. This involves, among other things, gold transactions on a reciprocal basis with all of these countries.

Works Progress Administration officials have little to say about the future. It is a fact, however, that the trend of thought and action is toward retrenchment and the reduction of overhead expenses. WPA officials are making a nation-wide survey with the object of curtailing expenses to the degree that the need for relief has diminished. Cuts are expected in administrative personnel and among non-relief workers.

Unofficial reports indicate dismissals before January 1, 1937, running up to 175,000. Of that number, 20,000 are expected to be non-relief workers and some 5,000 administrative employees. In that connection, it is interesting to note that only one out of every 93 persons working on relief projects is an administrative employee, and that dismissals are likely to be about one in 35.

The very strong indication remains, however, that Mr. Hopkins will urge the President to ask Congress for another $500,000,000 to continue WPA activities through June 30, 1937. This will probably be termed "drought adjustment" by congressional appropriation, and it may upset Secretary Morgenthau's assurances of no new taxes or increases in present tax rates.

Engineering Employment Situation

At no time in recent history has there been so much genuine interest in the use of a merit system in government service. The administration is said to encourage a "career service." The Civil Service Reform League, American Public Welfare Association, the several organizations of government employees, and the professional groups as well as the general public all seem equally enthusiastic about the possibilities of substituting personal merit for political or social preference in the selection of public employees.

Council's committees are being informed of this activity and of the related opportunity to improve the economic status of engineers in national, state, and local government service by supporting the merit system. The staff is using its contacts with congressional committees, the Civil Service Commission, and the Civil Service Reform League to promote the universal adoption of the merit system in the form of an expansion of Civil Service to include a more effective career service.

In the meantime, the elimination process is quietly moving thousands of emergency employees, including hundreds of engineers, into other activities. Many of the more capable who have strong personal endorsement of their fitness are being transferred "within the service." Personal politics and "social mindedness" still play their part in the selection of employees, but most administrative and personnel officers in Washington are displaying an encouraging disposition to fill vacancies with people possessed of proper qualifications, with preference for those of experience.

Washington, D.C.
December 7, 1936

Preview of Proceedings

By HAROLD T. LARSEN, *Editor*

At least two, and if possible three, major papers are scheduled for appearance in the January issue of "Proceedings." One deals with the design of superstructures, another with the ever-fascinating realm of earth pressures, and the third with sanitary engineering. There will also be a large number of interesting discussions on current papers.

STRUCTURAL ANALYSIS BASED UPON PRINCIPLES OF MODELS

Sometimes it seems that developments in the field of structural analysis tend toward greater and greater complexities as each new investigator conceives of new assumptions and new conditions to be met. In a paper entitled "Structural Analysis Based Upon Principles of Models," Otto Gottschalk, civil engineer of Buenos Aires, the Argentine Republic, offers a refreshing variation from this trend. In some of its aspects the simplicity of his logic is such as to make it appear to the reader that there is nothing essentially new in it. This may be true because not many concepts in structural analysis are new, but the paper nevertheless will be found worthy of study, and careful students are assured an insight into the subject, which they may not have possessed before.

The paper is essentially a method for computing influence lines. The author has managed to derive formulas that are very simple and easy to use and to remember. He has presented them in such form that the analysis of a series of any number of continuous beams, for example, becomes a continuous simple process. It may be that the theory has still further possibilities, which it is hoped discussion will reveal.

Quite properly, Mr. Gottschalk gives credit to Bernard L. Weiner, Assoc. M. Am. Soc. C.E., for a careful review of this paper before publication, in order to avoid delay in transmitting correspondence between Society Headquarters and Buenos Aires. Mr. Weiner generously consented to act as Mr. Gottschalk's agent tentatively, with the understanding that Mr. Gottschalk will have the privilege of incorporating minor final corrections, before his paper is published in TRANSACTIONS. Aside from this service, Mr. Weiner examined the paper in detail during the entire process of its preparation, and made important suggestions for changes. He contributed Appendices 1 and 2 to supplement the paper.

GRAPHICAL DETERMINATION OF FOUNDATION PRESSURE

A suggestion for computing, quickly, the distribution of vertical pressures beneath a foundation is contained in an excellent paper entitled "Graphical Determination of Foundation Pressure," by Donald M. Burmister, Assoc. M. Am. Soc. C.E. This method makes use of graphical principles that have been in process of development at Columbia University since early in 1934. The ease with which it may be applied, its accuracy and range, should commend it to foundation engineers. Vertical pressure may be computed in the soil at various depths and various horizontal distances from the foundation layout, which may be applied at several places on the surface of the soil.

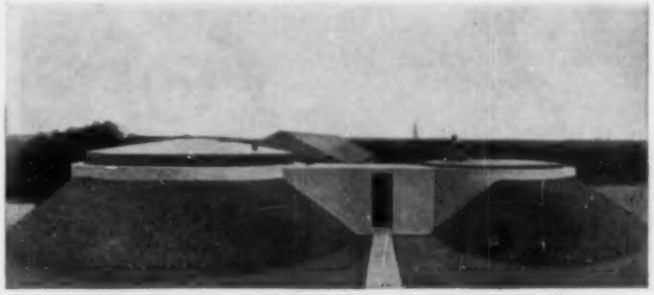
The author assumes that the soil acts as a homogeneous, elastic isotropic body, and applies Boussinesq's equations in its solution. The method involves the use of a table and diagrams and, all in all, should prove an interesting and valuable subject for discussion.

STANDARD PRACTICE IN SEPARATE SLUDGE DIGESTION

From the standpoint of the financial investment involved, as well as from that of sanitation, the disposal of sludge is an important part of the treatment of sewage. But progress in the methods of disposal has been so rapid that, on the whole, neither the principles of design nor the methods of operation have been thoroughly correlated. For that reason, the comprehensive report of the Committee of the Sanitary Engineering Division on Sludge Digestion should be welcomed by designers and operators alike.

This report begins with a brief description of sewage and of the end-products of digestion—gas and digested sludge. The effects on the digestion processes of important "environmental factors," such as temperature, pH, trade-waste content, and density, are then discussed. Next the various types of digestion equipment, from the early open tanks built of earth to the modern multiple-stage covered units, are described.

An especially helpful section of the report is that entitled "Computations of Tank Capacity and Heating Requirements." It is not altogether satisfactory, says the Committee, to base capacities empirically on an estimate of the contributing population or of the gallons of sewage per day, because of local differences in per capita quantities and in the strength of the sewage. Formulas based on the weight of solids removed, the percentage of volatile matter in the solids, and the water content of the sludge are therefore developed. Numerical examples indicate clearly their application to heated tanks with daily withdrawals, heated tanks with periodic withdrawals, and unheated tanks. Other formulas are provided for the computation of heat losses and heat requirements.



A TYPICAL MODERN SLUDGE DIGESTION INSTALLATION
The Tanks Are Equipped with Gas-Collection Devices and Banked with Earth to Reduce Heat Losses

The next section outlines the various methods for disposing of sludge after digestion, and the report closes with a discussion of operating routine. Two appendices are included, giving data on the operation of typical plants.

"Standard Practice in Separate Sludge Digestion" represents the work of many years on the part of the Committee, which consists of Samuel A. Greeley, chairman; and W. L. Havens, C. B. Hoover, C. E. Keefer, and John F. Skinner. A subcommittee of fourteen members also gave valuable assistance.

DISCUSSION

Critical comments on current papers have been especially numerous and interesting in the past few weeks, and for that reason the January issue of PROCEEDINGS will contain valuable reading material for members of widely differing professional interests. It will contain at least four closing discussions: "Sedimentation in Quiescent and Turbulent Basins," by J. J. Slade, Jr.; "Behavior of Stationary Wire Ropes in Tension and Bending," by Douglas M. Stewart, Jun. Am. Soc. C.E.; "Comparison of Sluice-Gate Discharge in Model and Prototype," by Fred W. Blaisdell, Jun. Am. Soc. C.E.; and "Modern Conceptions of the Mechanics of Fluid Turbulence," by Hunter Rouse, Assoc. M. Am. Soc. C.E.

New Manual on Filtering Materials

MARKING the culmination of about eleven years of work, the forthcoming Manual No. 13 on *Filtering Materials for Sewage Treatment Plants* deserves an important place among the working books on the bookshelf of every engineer interested in sanitary engineering.

It was in May 1925, three years after the organization of the Sanitary Engineering Division, that a committee was appointed to consider, not only the size of material, but also its proper preparation and physical and chemical characteristics. This committee of the Sanitary Engineering Division held its first meeting on October 10, 1925, after sounding out the prospective scope of its work by correspondence, and has held many meetings since, most of them two-day sessions. The committee has been composed of five members—William E. Stanley, chairman; W. H. Dittoe, George B. Gascoigne, James W. Armstrong, and Nathan T. Veatch, Jr., Members, Am. Soc. C.E. The personnel of the committee has remained the same throughout its work except for the

last two members, who were appointed in 1926. Progress reports have been published in PROCEEDINGS or in CIVIL ENGINEERING each year, making a record of the status of the committee work and its activities.

To record herein the names of all those who contributed time and knowledge to the material collated in this manual would indeed be a formidable task. In its researches the committee received the assistance of many cooperative men and agencies. At one time as many as thirteen testing laboratories collaborated with the committee. Suffice it to say that the committee has gathered a considerable store of valuable data, many items of which have appeared in the committee progress reports in the publications of the Society.

The finished manual is organized in two distinct parts, Part I being entitled "Material for Trickling Filters," and Part II, "Fine Grained Filter Materials." For purposes of practical reference, the body of the manual is relatively brief, details of various parts being expanded into five appendices, for those who wish to follow up some phase of the problem in greater detail. Not the least important of these appendices is a bibliography. Here again it has been necessary to select only the most important of an almost unlimited store of material available.

It is conservative to state that this manual should be a great aid to practicing sanitary engineers in their endeavors to work out the solutions of many troublesome problems pertaining to the choice of filtering materials for sewage treatment plants. The manual is expected to be in the mails for delivery to all members during the current month.

News of Local Sections

Central Ohio Section

The Central Ohio Section met for its monthly luncheon at the Chittenden Hotel in Columbus on November 19. There were 21 present to hear the guest speaker, Glen W. McCuen, chairman of the department of agricultural engineering at Ohio State University, discuss the subject, "Engineering from Highways and Byways." Professor McCuen, who served as a delegate to the international convention of agricultural engineers held in Madrid in the summer of 1935, gave an interesting account of his 5,800-mile motor trip on European highways made at that time, comparing European and American driving conditions.

Colorado Section

On November 9 members of the Colorado Section and their wives enjoyed the annual "ladies' night." The program for the occasion was arranged by D. P. Barnes, J. S. Hamilton, and F. C. Hart, all members of the Junior Association of the Section. Following dinner, there was a talk by E. F. Wilsey, former professor of engineering at Robert College, Istanbul, who discussed oriental rugs and brasses, illustrating his talk with parts of his personal collection. Several oriental dances were also enjoyed.

The Junior Association of the Colorado Section held a meeting in Denver on October 26. Carl J. Scheve, a junior engineer in the U. S. Bureau of Reclamation who has made several visits to Germany, contrasted conditions prior to the Hitler regime with those obtaining today. Another meeting took place on November 23, with 29 members and guests present. After a business session, an illustrated talk was given by A. W. Simonds, of the U. S. Bureau of Reclamation and formerly consulting engineer on the grouting of Madden Dam in the Canal Zone, who described Panama and the Madden Dam project. A general discussion followed. On November 14 about 100 members of the Junior Association and their guests made an inspection trip through the Brighton Plant of the Great Western Sugar Company near Denver. Part of the group is shown in the accompanying photograph.

JUNIOR ASSOCIATION OF THE COLORADO SECTION AND GUESTS INSPECT PLANT OF GREAT WESTERN SUGAR COMPANY, NEAR DENVER

Cleveland Section

An informal dinner meeting was held by the Cleveland Section on December 9 at the Cleveland Chamber of Commerce in honor of Daniel W. Mead, President of the Society. After informal discussion of various Local Section affairs, Howard S. Morse, Director of the Society, spoke briefly on problems of Society administration. Then Dr. Mead gave a talk on the aims and ambitions of the Society. On December 15 the Section, in cooperation with the Cuyahoga County Society of Professional Engineers, the Cleveland Engineering Society, and the Northern Ohio Chapter of the American Steel Warehouse Association, sponsored a lecture on the San Francisco–Oakland Bay Bridge. The speaker was C. F. Goodrich, chief engineer of the American Bridge Company.

Detroit Section

A joint dinner meeting of the Detroit Section and the University of Michigan Student Chapter took place at the Michigan Union in Ann Arbor on November 6. After the extension of greetings by Student Chapter members, Mortimer E. Cooley, dean emeritus of the colleges of engineering and architecture at the University of Michigan, gave an informal talk in which he sketched the careers of many important engineering graduates of the University. Daniel W. Mead, President of the Society, was then introduced by Vice-President Henry Earle Riggs. Drawing from the experiences of his long professional career, Dr. Mead gave an interesting and helpful talk. The attendance at this meeting, which was under the chairmanship of Prof. L. M. Gram, was 126, about two-thirds of this number being students.

District of Columbia Section

On November 14 members of the District of Columbia Section of the Society and the Washington Society of Engineers made a joint visit to the District of Columbia sewage disposal plant. Through the courtesy of Elwood Johnson, engineer in charge, the group was shown through this plant, which is now nearing completion. About 100 members and guests were present.

Duluth Section

A regular meeting of the Duluth Section took place on August 17, with 11 members and guests present. On this occasion a talk was given by Thomas Naylor, county attorney, on the work of his office in handling criminal prosecutions. There were 15 present at a meeting of the Section held on September 21. The speaker was George Larsen, who described the maintenance work of the Minnesota State Highway Department in the Duluth district. Another meeting of the Section took place on October 19, with 15 present. At this session Capt. A. O. Robideau described the U. S. Naval Reserve training in the seventh district. Then Col. F. C. Tenney, of the Reserve Corps of the U. S. Army, gave an illustrated talk on artillery training at the Fort Sheridan, Ill., summer camp.

Georgia Section

A luncheon meeting of the Georgia Section took place at the Atlanta Athletic Club on November 9. During the business session the nominating committee reported that the 1937 officers will be as follows: J. W. Barnett, president; F. C. Snow, vice-president; B. H. Hardaway, Jr., non-resident vice-president; and A. J. Cooper, secretary. The

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speaker was Judge David M. Parker, legal adviser to the state banking deparment, who discussed Georgia's finances as related to tax problems.

IOWA SECTION

There were 50 present at the eighteenth annual meeting of the Iowa Section, which was held in Des Moines on the afternoon and evening of November 19. During the business session the following officers were elected for the coming year: A. H. Holt, president; R. E. Robertson, vice-president; and R. B. Kittredge, secretary-treasurer. Several Student Chapter and committee reports were heard, and Mr. Kittredge gave an account of the Fall Meeting of the Society and of the Local Sections Conference held at that time. Other speakers were T. A. Leisen, Director of the Society; J. C. Detweiler, president of the Nebraska Section; and Daniel W. Mead, President of the Society, all of whom discussed different aspects of the topic, "Aims and Activities of the Society." After an informal dinner Dr. Mead again spoke—this time on the subject of water power.

KANSAS STATE SECTION

There were 52 members and guests present at a meeting of the Kansas State Section held at the Hotel Kansan in Topeka on November 16. After a brief business session E. B. Black, former Director of the Society, introduced Daniel W. Mead, President of the Society. Dr. Mead gave a talk on engineers' ideals. Among the guests were several members of the Kansas State College Student Chapter.

LOS ANGELES SECTION

An attendance of 200 members, one of the largest meetings in the history of the Los Angeles Section, was the testimony tendered two of the Section's distinguished members at a meeting held at the University Club on December 9. The guests of honor were Louis C. Hill, official nominee for President of the Society, and J. B. Lippincott, newly elected Honorary Member. They were introduced by H. W. Dennis, Vice-President of the Society. Henry E. Riggs, another Vice-President of the Society, was also present, as was Ivan C. Crawford, Director. The program consisted of addresses by H. A. Steiner, of the political science department of the University of California, and H. A. Van Norman, chief engineer and general manager of the Los Angeles Department of Water. Dr. Steiner discussed the war in Spain, while Mr. Van Norman showed slides of, and presented general information on, the 58,000-ft Mono Crater Tunnel now being built by the Department.

A meeting of the Junior Forum of the Los Angeles Section, held on the same evening, was addressed by Le Van Griffif, a senior at the California Institute of Technology. Mr. Griffif spoke on the design of elevated water-tank construction to resist earthquakes.

METROPOLITAN SECTION

Illustrated talks on the new Triborough Bridge were the principal feature of a meeting of the Metropolitan Section held in the Engineering Societies Building in New York City on November 18. The speakers were O. H. Ammann, chief engineer of the Triborough Bridge Authority, who introduced the subject and outlined the scope of the project; Allston Dana, engineer of design, who described the design of the bridge; and H. W. Hudson, engineer of construction, who discussed the erection of the structure. Of special interest was the description of the change in the design of the bridge structure from four-column to two-column towers after the work had been started. In spite of this, the project was completed as originally scheduled and now serves as the first connection between the three boroughs—the Bronx, upper Manhattan, and Queens. Refreshments were served at the conclusion of the meeting, which was attended by about 300.

MILWAUKEE SECTION

The annual joint meeting of the Milwaukee Section and the Marquette University Student Chapter took the form of a dinner held at the La Salle Hotel on November 12. In all there were 38 present, including 22 Student Chapter members. During the business session F. W. Ullius, secretary of the Section, gave a report of his trip to the Fall Meeting of the Society at Pittsburgh. Then E. D. Roberts, head of the department of civil engineering at Marquette University, who has recently returned from an extensive inspection tour of the Muskingum Valley Conservancy District, outlined the history of the project and described the general design features. An enthusiastic discussion followed.

NORTHEASTERN SECTION

There were 58 present at a meeting of the Northeastern Section, held in Boston, Mass., on November 21. After a brief business meeting, during which a progress report of the committee on general arrangements for the 1937 Fall Meeting of the Society was heard, the speaker of the occasion was introduced. This was Karl T. Compton, president of the Massachusetts Institute of Technology, whose subject was "Improving the Status of the Engineering Profession." Dr. Compton made special reference to the activities of the Committee on Engineering Schools of the Engineers' Council for Professional Development.

PHILADELPHIA SECTION

The San Francisco–Oakland Bay Bridge was the subject of the symposium presented at the November 18 meeting of the Philadelphia Section. There were 300 present at this session, which was under the chairmanship of Lester L. Lessig, while 135 attended the dinner preceding it. The first speaker on the program was C. F. Goodrich, chief engineer of the American Bridge Company, who gave an illustrated talk on the structure as a whole. Mr. Goodrich covered the construction of the bridge superstructure, including the spinning of the cables. Then George E. Beggs, professor of civil engineering at Princeton University, presented a paper on the construction and use of a model of the suspension spans of the bridge for the purpose of making a check on the results obtained from a design following accepted theoretical formulas. This demonstrated the remarkable accuracy of stress calibrations through the use of a correctly built model. By way of discussion, Jonathan Jones, chief engineer of fabricated steel construction for the Bethlehem Steel Company, then pointed out the importance of considering elastic deformations in the successful erection of extended steel structures. The last speaker on the program was John C. H. Lee, district engineer of the Philadelphia Engineer District. Colonel Lee described the various requirements that must be met before permission will be granted to construct a bridge over any navigable water in the United States.

ST. LOUIS SECTION

The St. Louis Section recently elected the following officers for 1937: J. H. Porter, president; W. C. E. Becker and J. T. Garrett, vice-presidents; and R. A. Willis, secretary-treasurer.

TENNESSEE VALLEY SECTION

The Muscle Shoals Area of the Tennessee Valley Section held a meeting on September 9, which was addressed by Philip B. Hill, a civil engineer for the Tennessee Valley Authority. Dr. A. J. Abrams was the speaker at the meeting held on October 14, and Lee G. Warren, project engineer on the Chickamauga Dam of the Tennessee Valley Authority, addressed the meeting held on November 11. The Knoxville Subsection held a meeting on November 5, which was in charge of vice-president Henry Fruend.

VIRGINIA SECTION

The fall meeting of the Virginia Section took the form of an all-day session held at the Virginia Polytechnic Institute at Blacksburg, Va., on November 14. In the morning the following speakers were heard: C. W. Ogden, assistant chief engineer of the Virginia Bridge and Iron Company; J. A. Anderson, professor of civil engineering at Virginia Military Institute and formerly acting state director for the PWA; and R. W. B. Hart, city manager of Lynchburg, Va. Two Juniors were also represented on the program. These were F. E. Graef, Jr., commander of Company 2030 of the Civilian Conservation Corps, and W. P. Croom, Jr., assistant city engineer of Danville, Va. G. W. McAlpin and A. N. Charrington, Student Chapter members, also gave short talks. Following this technical session, a luncheon was served at the Faculty Apartment House, and in the afternoon many members and guests attended a football game between Virginia Polytechnic Institute and the University of Virginia. This successful and well-attended meeting was arranged by a committee consisting of R. B. H. Begg, chairman, and F. P. Turner, C. W. Ogden, and E. S. Thomas.

Student Chapter Notes

Case School of Applied Science

In November the Case School of Applied Science Student Chapter enjoyed a smoker, at which there were two interesting speakers. John M. Belknap, area engineer of the Loudonville Area of the Zanesville District, described the construction features of the various dams in his district. The other speaker was an honored guest of the School and Student Chapter, Volmar Fellenius, dean of civil engineering at the University of Stockholm. Dr. Fellenius related his impressions of the major construction enterprises in the United States.

Kansas State College

The Kansas State College Student Chapter held a meeting in honor of Daniel W. Mead, President of the Society, on November 16. Following a dinner that took place at the Gillette Hotel in Manhattan, Kans., Dr. Mead gave a special talk for the Student Chapter members. In this talk he described the function of the Society and emphasized the importance of sound engineering and administrative principles.

Group from the Kansas State College Student Chapter with Dr. Mead

Lewis Institute

There were 20 present at a recent meeting of the Lewis Institute Student Chapter, at which the Society's illustrated lantern lecture on the Cascade Tunnel was enjoyed. Various Student Chapter activities were also discussed at this session.

New Mexico State College

The New Mexico State College Student Chapter was especially interested in the Society's illustrated lecture on Norris Dam because members of the Chapter recently made a trip to the dam. Sixteen days were spent on this inspection trip, which included visits to many other points of engineering interest in the South as well—Wilson Dam, Chickamauga Dam, Wheeler Dam, Alcoa Dam, the New Orleans Bridge, the New Orleans Water Works, and the Knoxville Water Works, to mention a few. One of the group making the trip made interesting comments on Norris Dam, in connection with the showing of the slides. Over 4,500 miles were covered in the course of the trip.

Pennsylvania Military College

The Pennsylvania Military College Student Chapter was fortunate in having for its November meeting a special group of speakers. These were C. E. Myers, Director of the Society and consulting engineer of Philadelphia, Pa., who spoke on the value of membership in the Society to the young engineer; Joseph G. Shryock, chief engineer of the Belmont Iron Works, who discussed culture as a factor in professional success; Col. Frank K. Hyatt, whose topic was the advantage of an engineering education; and Walter E. Jessup, Field Secretary of the Society, who spoke on the promise of the future for the engineer.

University of Dayton

The Society's illustrated lectures on the flood-control system in the Miami Valley recently proved of special interest to the University of Dayton Student Chapter, as many members of the Chapter live in this area and realize the value of the flood-control system. After the presentation of the lecture Bernard T. Schad, dean of the college of engineering at the University, commented on the flood-control project.

University of Michigan

A joint meeting of the University of Michigan Student Chapter and the Detroit Section of the Society took place in Ann Arbor, Mich., on November 6. At this meeting the Student Chapter initiated the largest number of students in its history—41 men and one woman. A full account of this meeting appears under the head of the Detroit Section in the "News of Local Sections" department of this issue of Civil Engineering.

University of Texas

On November 7 the junior-class members of the University of Texas Student Chapter visited the partially completed Buchanan Dam. The inspection trip was made under the auspices of P.M. Ferguson, associate professor of civil engineering at the University, who was employed during the past summer on the redesign of the small arches in one part of the dam. On November 14 the senior-class members of the Student Chapter made the same trip. Professor Ferguson was assisted on this trip by John A. Focht, professor of highway engineering at the University. A joint meeting of the Student Chapter and the Austin Technical Club was held at the University of Texas on November 12. The speaker on this occasion was J. C. Carpenter, senior highway engineer of the U. S. Bureau of Public Roads at Fort Worth, who discussed the mapping of large areas.

University of Wisconsin

The Society's lantern slides on Wilson Dam were shown at a recent meeting of the University of Wisconsin Student Chapter. In connection with the showing of these slides, A. T. Lenz, instructor in hydraulics and sanitary engineering at the University, commented on this project and on Norris Dam. A short business meeting preceded the lecture, and refreshments were served afterwards.

Washington University (Collimation Club)

The Collimation Club of Washington University is celebrating the thirtieth anniversary of its founding during the present school year, as it was organized in October 1906. The Club, which became affiliated with the Society as a Student Chapter in 1920, has a continuous and complete record of all events since its organization. For this year's program special efforts are being made to obtain speakers who are either former members of the Club or who were connected with the University during the past thirty years. It is the belief of the present membership that the Collimation Club of Washington University is one of the oldest student civil engineering societies in the United States. The accompanying photograph shows a suspension bridge constructed by the Student Chapter. Between anchorages there is a span of 285 ft, and between towers of 165 ft. The towers, 29 ft in height, are constructed of telephone poles.

Suspension Bridge Constructed by Washington University Student Chapter, St. Louis

ITEMS OF INTEREST

Engineering Events in Brief

Civil Engineering for February

Among the articles scheduled for the February issue is one by Robert B. Brooks, M. Am. Soc. C.E., consulting engineer of St. Louis, Mo., describing the international highway now being constructed across Europe from London to Istanbul. This 2,000-mile route, which passes through no less than nine different countries, consists at present of roads varying from modern hard-surfaced highways to primitive cart-tracks. That section of the road between London and the southern boundary of Hungary has already been modernized or constructed new, and the remaining 40 per cent to Istanbul is scheduled for completion in the near future.

A third paper on the life and works of Thomas Telford, pioneer in bridge, road, and canal construction, by J. F. Baker, Assoc. M. Am. Soc. C.E., professor of civil engineering at the University of Bristol, England, and John Armitage, is also scheduled for the February number. This article deals with Telford's achievements in draining the Fens in eastern England, constructing a system of roads in Scotland, and reconstructing a road across Wales from Holyhead to Shrewsbury. The major parts of these works were constructed in the post-Napoleonic period, from 1815 to 1830. While the use of the term "Telford base" to designate road foundations composed of large stones placed on end is familiar to most engineers, few realize that Telford not only built the first road of this modern type, but also fathered our present system of carrying out public works by contract.

During the critical spring months, when the waters of the Mississippi are rising towards the levee tops, the probable height of the flood becomes a question of great importance to every dweller near the river from Cairo to the Gulf, as well as to engineers attempting to control the flow. An article by E. W. Lane, M. Am. Soc. C.E., professor of hydraulic engineering at the University of Iowa, describes a successful method for predicting such flood stages in advance. This method, which has been evolved from a detailed study of years of record, is subject to modifications in the vicinity of large tributary streams. The procedure for determining the gage-lowering due to crevasses is given special attention.

In a second article dealing with speed versus safety on highways, R. A. Moyer, Assoc. M. Am. Soc. C.E., associate professor of highway engineering at Iowa State College, discusses skidding on curves and the effect of uneven surfaces on control. As automobile speeds continue to increase, avoidance of surface irregularities is becoming more important. Other things being equal, the critical speed of a car rounding a curve depends upon its steering angle (measured by position of the steering wheel) and slip angles (positions of the front and rear wheels with reference to the car's line of travel). If curves and grades were designed to provide a uniform frictional factor of safety of 3 or 4, says Professor Moyer, motor vehicles could operate safely at the maximum speed established for each class of highway.

Etching of George Westinghouse Bridge for Cover Illustration

On the front cover of this issue appears a halftone reproduction of an original etching by Otto Kuhler, eminent industrial designer, depicting his impression of the George Westinghouse Memorial Bridge in Pittsburgh, Pa. This etching was made expressly for the Society in the interest of the Fall Meeting, which featured as part of its program the structural application of steel and light-weight alloys. Many of the papers presented at the Meeting are abstracted in this issue.

In his striking view Mr. Kuhler has shown this reinforced concrete arch bridge framing a part of the industrial activity which has given Pittsburgh the name of "The Steel City." Having first visualized this composition in his New York studios, he went to Pittsburgh, picked the spot he had chosen in his mind's eye, and made his sketch. On his return he completed the etching, with the results shown.

Readers of Civil Engineering will see that a cover format different from that regularly used appears this month. This was also suggested by Mr. Kuhler, to be in keeping with the subject treated and with the proportions of the finished etching. Some of his etchings which have been used in past numbers are "Giants on Call," on the June 1931 cover; "The Steel Castle," on the page of special interest for February 1932; and the "Prettyboy Dam," on the November 1933 page of special interest. Civil Engineering is grateful for the courtesy extended in the past by the various galleries and owners of Mr. Kuhler's etchings. It is indebted to him also for his willing cooperation in carrying to fulfilment this excellent idea for typifying the spirit of Pittsburgh.

Wise and Otherwise

The following ingenious problem is submitted by Professor E. L. Ingram, M. Am. Soc. C.E.

In a suit to recover damages for the death of a man struck by a train on a railroad trestle it was alleged that the train failed to whistle 1,000 ft before it reached the trestle, as required by law. Professor Abercrombie, who had been called in by the defense, succeeded in exonerating the engineman by proving that when the men heard the whistle the train was in excess of 1,000 ft from the end of the trestle. The evidence showed that the two men had attempted to cross the trestle side by side and that 20 ft before reaching the center they had heard the train whistling behind them. Panic-stricken, one man ran towards the approaching train and cleared the trestle just in time. The other man, in whose name the suit was brought, ran away from the train with equal speed, but was killed one foot from the far end of the trestle. It further appeared that the speed of the train was eight times as fast as that of the men. Where was the train when the men heard the whistle?

December's problem involved three persons, A, B, and C, sitting together in a room. They have each been touched on the forehead by Professor Abercrombie, and each has been instructed to start whistling as soon as he sees a black mark on anyone's forehead and to stop as soon as he feels certain that there is a black mark on his own forehead. There is to be no other communication. All begin to whistle, as each forehead has in fact been marked. After a considerable time, A stops whistling. How has he reasoned?

In solving this problem, it is assumed that all three persons are capable of deduction. A sees that the foreheads of B and C are both marked, so he has a double reason to start whistling. He also hears B and C whistling but cannot, of course, determine immediately whether this is on account of his own (problematical) or B's and C's (evident) markings. If A were not marked, however, that fact would be evident to B, who would reason that C whistled because of his (B's) mark, and who would therefore have a basis to cease whistling. C would reason similarly, and would also stop. Allowing B and C "a considerable time," that is, sufficient to enable them to perform the above processes and acts, A concludes that B and C each see two marked foreheads, just as A does, and therefore that his own forehead is marked. A accordingly stops whistling. Of course, B and C can come to the same conclusion as regards themselves by a similar course of reasoning, but A demonstrates that he thinks quickest by stopping first.

Suggestions for other problems for Professor Abercrombie's column, accompanied by solutions, may be addressed to the editor. Solutions should preferably be sent in separate enclosed envelops.

First Organized Irrigation in Colorado

By R. E. VAN LIEW

JUN. AM. SOC. C.E., JUNIOR CORRESPONDENT FOR "CIVIL ENGINEERING," COLORADO SECTION, DENVER, COLO.

HIGHLAND IRRIGATION in Colorado was first attempted and developed to a practical state in the vicinity of Greeley, by members of the Union Colony. The project is of special interest for it led directly to the first state law relating to the distribution of water, which, as the "Colorado Plan," was later adopted by most of the other western states.

Before the Civil War, a few scattered and feeble attempts had been made by individual ranchers to irrigate bottom lands near the mountains. But the results were generally unsatisfactory, and the ranchers made little effort to extend their systems. They did not realize that the uplands were of any value, and when the Greeley colonists began their project in 1870, the dwellers in the river bottoms laughed at them for settling on the cactus.

But the Greeley project was a success. The colonists, who had originally taken up 12,000 acres, gradually extended the area under irrigation and cultivation to 230,000 acres. The reservoir system grew until it covered some 6,000 acres, and the main canals extended several hundred miles. The number of irrigators increased to 2,000.

There were no experienced irrigators in the community. Difficulties had to be met as they arose, and overcome in pioneer fashion—by native sense. The construction of each ditch presented its own peculiar problems.

Since there was no public administration or law governing the rights to water, conflicts over water claims had to be settled by force or by tact. Under these conditions the ditches nearest the source of the river were more certain to receive water, while lower ditches did not always get their share. The Greeley diversions were in the latter group, and it was soon evident that administration was necessary.

But the Fort Collins settlers, up river, were not willing to give up any of their claimed rights, so the Greeley colonists went still further upstream and began to construct canals leading to their own holdings. It was not long before their neighbors saw the advantage of a public office to divide the water under a priority system as the principle of just distribution.

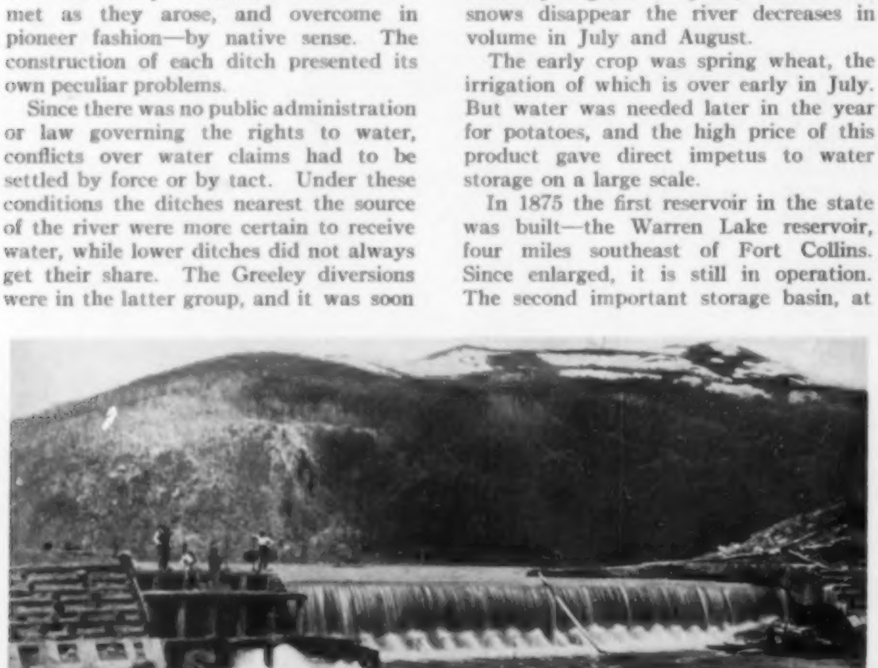
This movement led to the formulation of a state law whose provisions are now widely known as the Colorado Plan. This provides that a set of officers, known as state commissioners, shall have charge of the distribution of water as determined by the courts. The state is divided into districts, with a commissioner in each one. Where several canals draw water from the same stream or its tributaries, a superior officer, the water superintendent, is named to divide the water justly among them. The state engineer's office is over the commissioners and superintendents.

As the land under the Greeley ditches became cultivated, the demand for water became greater than the river could supply for at least a part of the year. The melting snows form the principal source of supply for the Poudre; the stream is normally highest in June, and as the snows disappear the river decreases in volume in July and August.

The early crop was spring wheat, the irrigation of which is over early in July. But water was needed later in the year for potatoes, and the high price of this product gave direct impetus to water storage on a large scale.

In 1875 the first reservoir in the state was built—the Warren Lake reservoir, four miles southeast of Fort Collins. Since enlarged, it is still in operation. The second important storage basin, at Chambers Lake, was added in 1882 and rebuilt ten years later. The accompanying pictures of it, taken some forty years ago, were made available through the courtesy of A. A. Edwards of Fort Collins.

The old Greeley Union Colony irrigation system is still in operation and ranks as one of the best in the state of Colorado. It comprises what is now known as Greeley System No. 2 and Greeley System No. 3.



THE SECOND IMPORTANT IRRIGATION RESERVOIR BUILT IN COLORADO
Chambers Lake Dam, Across the Poudre River, as Rebuilt in 1892

THE SKYLINE CANAL, DIVERTING LARAMIE RIVER WATER TO CHAMBERS LAKE, WAS BUILT BETWEEN 1891 AND 1895

Fourth Edition of "Who's Who in Engineering"

A NEW volume of *Who's Who in Engineering*, representing the fourth edition of that work, will be issued shortly, according to a recent announcement. The last previous edition appeared in 1931.

Because of the long delay in revision caused by general economic conditions, a thorough re-canvass of the entire engineering profession has been attempted, and to this end a list of engineers compiled through the Department of Labor was used. Invitations to supply data were also issued to a large number of engineers who had been recommended for inclusion since the last revision. The questionnaires used for this purpose carry three classifications, within one or more of which all persons listed must qualify.

Leaders of the various branches of the profession have been asked to sponsor the new volume. Andrey A. Potter, president of American Engineering Council, serves as chairman of the sponsoring committee, and A. W. Berresford, D. S. Kimball, C. F. Scott, George T. Seabury, Secretary Am. Soc. C.E., C. E. Davies, H. H. Henline, A. B. Parsons, J. F. Coleman, Past-President Am. Soc. C.E., and F. M. Feiker are committee members. *Who's Who in Engineering* is published by the Lewis Historical Publishing Company, Dr. Winfield Scott Downs, managing editor.

Diesel Anniversary

A group of engineers, industrialists, and publishers to the number of almost 500 gathered at a luncheon in New York on December 2, 1936, to honor the memory and accomplishments of Rudolf Diesel, who devoted much of his brilliant life to developing the famous internal combustion engine which now bears his name. Approximately forty years have passed since the first Diesel engine was tried out in America, yet the immense possibilities of its development are only beginning to be realized.

Curiously enough, Diesel himself died in 1913, before his invention had really established itself. From that time on until the depression years, it had a continuous and healthy growth. By 1932, however, the production had declined until it approximated that of 1915. It is since 1932 that the phenomenal increase in the total Diesel horsepower sold, has taken place, from about 100,000 hp in that year to 750,000 in 1934, and over 2,000,000 probably in 1936.

Dr. Rudolph Diesel (1858–1913), Inventor of the Diesel Engine

Almost every type of power use is represented in the modern Diesel category. In the application of these the civil engineer is interested, as illustrated by the phenomenal growth in the use of Diesel-powered trucks and tractors, earth-handling machinery, and the like. Another prominent use is in the light-weight high-speed railroad train, which also seems to be on the threshold of important developments. Motor ships utilizing this economical source of energy are now quite common. Even for municipal and industrial power plants, the Diesel engine is finding a definite use; one of the important installations, at Vernon, Calif., was described in detail in the September 1935 issue.

In short, it may be said that the era of Diesel power seems to have arrived. Its future development offers almost unlimited possibilities. The recent honoring of Mr. Diesel is simply a recognition of the significance of the most recent advances particularly in America.

Engineering Examiners Hold Annual Meeting

The National Council of State Boards of Engineering Examiners held its seventeenth annual meeting in Knoxville, Tenn., on October 19–21, 1936. Twenty-five state boards sent official delegates, and seven national engineering groups had representatives in attendance. The Society was represented by its President, Secretary, and Field Secretary.

Officers for the ensuing year include: president, Prof. J. S. Dodds, M. Am. Soc. C.E., Ames, Iowa; vice-president, Prof. S. H. Graf, Corvallis, Ore.; former president, James L. Ferebee, M. Am. Soc. C.E., Milwaukee, Wis.; director of western zone, K. C. Wright, M. Am. Soc. C.E., Salt Lake City, Utah; director of southern zone, Prof. C. L. Mann, M. Am. Soc. C.E., Raleigh, N.C.; director of central zone, Dean R. A. Seaton, Manhattan, Kans.; director of northeast zone, C. G. Massie, Lynchburg, Va.; and executive secretary, T. Keith Legaré, M. Am. Soc. C.E., Columbia, S.C. The following men were designated as chairmen of the standing committees: Accredited Engineering Schools, Dean P. H. Daggett; Uniform Examinations for Registration, C. T. Olmsted; Legal Procedure, C. C. Knipmeyer; Constitution, S. H. Graf; National Bureau of Engineering Registration, Ralph J. Reed, M. Am. Soc. C.E.; and Engineers' Council for Professional Development, D. B. Steinman, M. Am. Soc. C.E.

Consideration of the reports of the various standing committees, and the round-table discussion of problems and methods of state boards, made up the principal business of the convention. The secretary's report showed that the membership of the Council now consists of 35 legally constituted state boards, which have a total of over 40,000 registered engineers and surveyors.

Tunnel Renamed in Honor of George Ward

The name of the Florence Lake diversion tunnel was recently changed to George Ward Tunnel by the Southern California Edison Company in honor of the late George Clinton Ward, M. Am. Soc. C.E. Mr. Ward, who died on September 11, 1933, was chief engineer of the tunnel. A ceremony, held at the site on August 26, 1936, included the unveiling of a tablet in Mr. Ward's honor. The tablet, which is shown in the accompanying photograph, bears the following inscription:

"Outlet of Ward Tunnel, named by the Southern California Edison Company Ltd., honoring George Clinton Ward, 1863–1933, who directed construction of the entire hydroelectric development of the Company on the San Joaquin River and its tributaries. This tunnel diverts the waters of Mono Creek, Bear Creek, and the South Fork of the San Joaquin

Tablet Memorializing Services of George C. Ward in Constructing Diversion Tunnel

River under the Kaiser Ridge into Huntington Lake. Constructed in 1920–1925; length 67,620 feet; diameter 15 feet; capacity 2,500 cubic feet per second."

NEWS OF ENGINEERS

Personal Items About Society Members

Clarence D. Howe is now minister of the recently organized Canadian Department of Transport, which has taken over the duties of the former Railways and Canals Department, the Marine Department, and the civil aviation branch of the National Defense Department.

Comfort A. Adams, who has been professor of engineering at Harvard University since 1906, is with the Edward G. Budd Manufacturing Company in Philadelphia, Pa.

August L. Ahlf, formerly junior engineer in the inspection division of the Denver Public Works Administration, now is junior engineer in the Denver office of the U. S. Bureau of Reclamation, where he is engaged on the design of reinforcing steel.

John W. Hopkins has resigned as district bridge engineer for the Pennsylvania Department of Highways to become connected with the Bessemer and Lake Erie Railroad Company at Greenville, Pa.

Frank R. Gollon is now with the U. S. Coast and Geodetic Survey in Washington, D.C., where he is employed as a junior cartographic engineer. He was formerly chief of party for the WPA in Brooklyn, N.Y.

J. C. Behrens is now employed as an assistant civil engineer in the Division of Land Planning and Housing of the Tennessee Valley Authority at Knoxville, Tenn. Formerly he was a draftsman in the Oregon State Highway Department, engaged on a state-wide highway planning survey.

NEIL C. HOLDREDGE, previously deputy chief engineer of the North Jersey District Water Supply Commission at Pompton Plains, N.J., has become division engineer for the Board of Water Supply of New York City. He is located at Newburgh, N.Y.

PHILIP CRAVITZ, previously design engineer for the Los Angeles County Flood Control District, is now construction superintendent for Contracting Engineers, Inc., Los Angeles, Calif.

WILLIAM N. BROWN has returned to private engineering work with W. N. Brown, Inc., of Washington, D.C. For the past six months Mr. Brown has been with the U. S. Department of Agriculture in charge of the use of aerial photography in measuring the acreage of fields and crops.

WILLIAM P. LIPSCOMB has resigned from the St. Louis County (Missouri) Highway Department to become engineer of the division of structural steel tunnel lining of the Ingot Iron Railway Products Company, of Middletown, Ohio, an affiliate of the American Rolling Mill Company.

ALMA PRATT, formerly engineering technical foreman for the U. S. Soil Conservation service at Price, Utah, has accepted a Civil Service appointment as junior road engineer for the Carson Indian Agency at Nixon, Nev.

JOHN A. CLARK was recently appointed superintendent of the new sewage-disposal plant at Medford, Ore. Previously he was sanitary engineer for the Alameda County (California) Mosquito Abatement District.

EDWARD C. SHERMAN has resigned as project manager in the Bureau of Yards and Docks of the U. S. Navy Department in Washington, D.C., to resume his consulting practice at 2583 Ontario Road, N.W., in the same city.

GEORGE D. CLYDE, formerly professor of civil engineering at Utah State Agricultural College and irrigation and drainage engineer for the Utah Agricultural Experiment Station, has been appointed dean of engineering and mechanic arts at the College.

W. P. ECKERLE has been promoted from the position of district engineer for the Kentucky Department of Highways to that of financial manager of the statewide planning survey of this Department. He is located at Frankfort, Ky.

WILLIAM E. STANLEY, hydraulic and sanitary engineer with Pearse, Greeley and Hansen, of Chicago, Ill., has been appointed professor of sanitary engineering in the school of engineering at Cornell University.

HIBBERT M. HILL, who was previously senior engineer in the U. S. Engineers Office at St. Paul, Minn., has become superintendent of the St. Anthony Falls Water Power Company in Minneapolis, Minn.

JOHN B. MORRISON is now vice-president of the Shelt Company at Elmira, N.Y. Formerly he was manager of sales and chief engineer of the Ohio Corrugated Culvert Company, at Middletown, Ohio.

HARRY E. JORDAN has resigned as chemical engineer for the Indianapolis (Ind.) Water Company to become executive secretary of the American Water Works Association. Mr. Jordan joined

HARRY E. JORDAN

the staff of the Indianapolis Water Company as a chemist in 1903, and since 1911 has been in charge of the purification plant. He has been identified with the activities of the American Water Works Association since the formation of the Indiana section of the Association in 1908 and has also played an active part in the technical and administrative functions of the national organization.

WILLIAM H. CRITSER has resigned as designing engineer in the Division of Engineering and Construction of the City of Columbus, Ohio. He is now on active duty as a first lieutenant, Corps of Engineers, U. S. Army, attached to the Pittsburgh District Office, where he is engaged in flood control and navigation work.

HARDY CROSS, after many years on the engineering faculty at the University of Illinois, has recently been appointed professor of civil engineering at Yale University, effective next fall. He will also be the director of graduate studies and act as chairman of the department of civil engineering. He is particularly known for developments in rigid-frame analysis. The original method of analysis, published in PROCEEDINGS for May 1930, was widely discussed and won for him the Norman Medal in 1933.

EDMUND T. RIDGWAY is now in the engineering department of the Edward G. Budd Manufacturing Company, Philadelphia, Pa. He was formerly a supervisor for the U. S. National Park Service at Berlin, N.J.

ROLAND R. SMALL, previously assistant construction engineer in the topographical Division of the Parks Department, New York City, has become construction engineer for the P. T. Cox Contracting Company, of the same city.

STANLEY H. WRIGHT has been appointed state director of the Public Works Administration for North Carolina, not acting state director, as was reported in the December issue.

CHARLES E. RIGGS is now chief of party for the California State-Wide Highway Planning Survey, functioning in cooperation with the U. S. Bureau of Public Roads, at El Cerrito, Calif. He was previously field engineer for Joint State Highway District 13, at Oakland, Calif.

FREDERICK W. DOOLITTLE, vice-president of the North American Company, New York City, and an officer and director of a number of its affiliated companies, has retired from executive work. He will continue as a director of the Company.

C. A. BULLEN, formerly chief engineer for the Dolese Brothers Company, of Oklahoma City, Okla., is now superintendent of the W. S. Bellows Construction Company, of Houston, Tex.

CECIL K. CALVERT has resigned as superintendent of sewage treatment and garbage reduction for the city of Indianapolis, Ind., to accept the position of chemical engineer with the Indianapolis Water Company.

WILLIAM N. CERVINO is now supervising senior engineer for the Riparian Streams and Waterways Survey of Passaic County, New Jersey, Paterson, N.J. He was formerly senior engineer in charge of a road construction project at West Milford, N.J.

RUSSELL W. ABBOTT, previously with Shoecraft, Drury, and McNamee, consulting engineers of Ann Arbor, Mich., has entered the employ of Forster, Wernert, and Taylor, industrial engineers of Toledo, Ohio.

MAX W. KING recently resigned his position with the Lower Colorado River Authority on the construction of Buchanan Dam. He is now superintendent of construction for the Comision Nacional de Irrigacion on the El Azucar Dam on the San Juan River, Tamps, Mexico.

JAMES W. JACKSON has resigned as assistant engineer of structural design in the U. S. Bureau of Reclamation at Denver, Colo., to become structural designer for the Carbide and Carbon Chemicals Corporation in Charleston, W.Va.

CHARLES A. EMERSON, JR., formerly consulting engineer for Fuller and McClintock, of New York City, has been made manager of the newly opened New York office of George B. Gascoigne and Associates, consulting sanitary engineers. This office will be operated as an adjunct to the Cleveland office of the same firm.

LAURENCE B. CHENEY, formerly regional engineer of state projects for the Connecticut State Emergency Relief Administration, has been appointed assistant director in charge of professional and service projects for the Connecticut WPA.

MILTON E. CROSBY, of Kansas City, Mo., has become manager of the Chicago office of the Nicholson Company, engineers and contractors.

CLARENCE M. HAWKINS is now an associate engineer for the National Park Service in Washington, D.C.

ROBERT A. VOELKER, formerly with the Francis Engineering Company, of Saginaw, Mich., has entered the employ of the Hamilton County (Tenn.) Regional Planning Commission, where he is senior engineer on flood-control surveys. His headquarters are in Chattanooga, Tenn.

F. RICHARD HAUBER is now superintendent of the Penker Construction Company, of Cincinnati, Ohio. He was formerly junior structural engineer for the division of highways of the Cincinnati Department of Public Works.

L. W. STEWART recently resigned his position as senior foreman engineer in the Department of the Interior to accept an appointment as resident engineer inspector for the U. S. Bureau of Public Roads, with headquarters in Jackson, Miss.

DECEASED

WILLIS EDWARD AYRES (M.'10) consulting engineer of Memphis, Tenn., for many years, died there on November 8, 1936. Mr. Ayres was born in Osceola, Ark., in 1876, and was educated at the University of Arkansas. In 1906, after six years' experience with the St. Francis Levee District of Arkansas, the U. S. Government in Cuba, and the Mississippi Valley Railway Company, he established a consulting and construction practice in Memphis. Mr. Ayres was active in the construction of flood control and drainage works, having built many of the larger drainage systems in Arkansas, Mississippi, and Missouri.

JOHN CAPRON BALCOMB (M. '20) a civil engineer on the staff of the New York World's Fair 1939, Inc., died in New York City on November 25, 1936. Mr. Balcomb, who was 58, was born in San Diego, Calif. His early experience included three years with the Santa Fe Central Railway and four years with the Chicago, Milwaukee, and St. Paul Railway. From 1911 to 1915 he was with the Rio de Janeiro (Brazil) Tramway, Light, and Power Company, Ltd., in charge of all engineering, and later he was division engineer for the Chile Exploration Company. For several years Mr. Balcomb was engineer in charge of construction for Stevens and Wood, Inc., and from 1934 until 1936 he was field engineer for Parsons, Klapp, Brinckerhoff, and Douglas.

WILLIAM I. BAUCUS (M. '08) city engineer of Northampton, Mass., died there on November 6, 1936. Mr. Baucus was born at Hoosick, N.Y., on March 31, 1866, and graduated from Rensselaer Polytechnic Institute in 1887. His early career included experience with W. and L. E. Gurley, manufacturers of mathematical instruments; the Metropolitan Water Board of Boston, Mass.; and the North Adams (Mass.) Marble and Milling Company. From 1904 to 1907 he was with the Isthmian Canal Commission, and from 1912 to 1918 was with the Department of Public Works of Santo Domingo, acting as consular agent of the United States at San Pedro de Macoris during the war. From 1919 to 1924 Mr. Baucus was city engineer of North Adams, Mass., and in the latter year became city engineer of Northampton.

The Society welcomes additional biographical material to supplement these brief notes and to be available for use in the official memoirs for "Transactions."

PARKE LOWE BONEYSTEELE (Assoc. M. '28) with the American Bitumuls Company, San Francisco, Calif., died on October 9, 1936, at the age of 46. Mr. Boneysteele was born at Bellaire, Ohio, and was educated at Ohio State University. From 1913 to 1917 he was transitman on the design, construction, and inspection of railway grade-separation structures and pavements for the city of Columbus, Ohio. In 1919, after two years in the U. S. Army, he became connected with the Nevada Department of Highways, where he remained until 1927. In 1930 he entered the employ of the American Bitumuls Company and served as district manager of this organization in several cities.

SAMUEL GOURDIN GAILLARD (M. '12) retired civil engineer of New Haven, Conn., died in that city on November 17, 1936, at the age of 77. Mr. Gaillard was born at Eutawville, S.C., and graduated from Union College in 1881. From 1884 to 1896 he was with the Norfolk and Western Railroad as assistant engineer, engineer in charge of construction, and finally as assistant to the president. In 1896 he entered the employ of the Mack Manufacturing Company, where he remained for over twenty years as consulting engineer and vice-president. Later he was manager of claims for the General Asphalt Company, Philadelphia, Pa., retiring from this position in 1931.

WILLIAM ADAM FARISH (M. '22) chief engineer of the Wittmann Projects at Wickenburg, Ariz., died in Los Angeles, Calif., on April 29, 1936. Mr. Farish, who was 65, was born in San Francisco, Calif. From 1894 to 1903 he was manager and engineer for the Arizona Water Works and Sewerage Company at Phoenix, Ariz.; and from 1903 to 1914 he was with the U. S. Reclamation Service—as assistant engineer for two years and later as engineer in responsible charge of surveys and construction. In 1917 and 1918 he was superintendent of construction for the Imperial Irrigation District. After several years on general irrigation engineering work, he became chief engineer of the Wittmann Projects.

RICHARD CARMICHAEL HOLLYDAY (M. '03) captain, CEC, U. S. Navy (retired) died at his home at Easton, Md., on November 17, 1936. He was 77. Captain Hollyday was born at Easton and was educated at Washington and Lee University. In 1894 he was commissioned a lieutenant, junior grade, in the civil engineering corps of the U. S. Navy. He was made a commander in 1907 and later in the same year was named chief of the Bureau of Yards and Docks, with the rank of rear admiral. At the conclusion of his four-year term as chief of the Bureau, during which he supervised construction of the Navy's system of drydocks, he reverted to the rank of captain, which he had attained in 1911. He was then assigned to duty as public works officer of the U. S. Navy Yard in Washington and was later transferred to other stations. In 1923 he retired from the Navy.

GULIAN SCHMALZ HOOK (M. '01) of Schenectady, N.Y., died there on November 5, 1936. Mr. Hook was born in 1862 and graduated from Union College in 1883. His early engineering career included considerable experience in railroad work and sewer construction. Among the cities for which he constructed sewerage systems are Amsterdam and New Rochelle, N.Y. From 1895 to 1899 he was resident engineer (at Rome and Oneida, N.Y.) for the Stanwix Engineering Company, in charge of surveys for water supply and of sewer construction. He then became assistant engineer for Schenectady in charge of sewer construction, and later was civil engineer for the General Electric Company, of Schenectady.

RALPH LONG KELL (Assoc. M. '16) city engineer of Lancaster, Pa., died on May 24, 1936, at the age of 54. Mr. Kell was born at Loysville, Pa., and graduated from Pennsylvania State College in 1905. Following graduation, he entered the employ of the Pennsylvania Railroad Company where he served for many years first as rodman, later as transitman on surveys, stream gaging, and railroad improvements, and finally as assistant supervisor of track on railroad extensions, grading, dredging, and grade-crossing elimination. In 1935 Mr. Kell became city engineer of Lancaster.

FREDERICK EWBANK LEEFE (M.'13) assistant engineer in the U. S. War Department at Portland, Ore., died in that city on September 22, 1936. Mr. Leefe was born at Fort Lyon, Colo., on July 16, 1874, and graduated from the University of Michigan in 1901. Much of his career was spent in the service of the War

Department, which he entered in 1893 as a rodman. In 1904 he became a U. S. junior engineer, being engaged on the construction of locks on the Allegheny River and, later, of dams, jetties, and the Celilo Canal in Oregon. From 1918 to 1929 Mr. Leefe was in the employ of various civil organizations, including the Portland Electric Power Company and the city of Portland. From 1930 until his death he was an assistant engineer in the War Department, engaged in hydrographic studies of the Columbia River and office studies for the Bonneville Dam.

JOHN BIGGER LEEPER (Assoc. M. '00) retired civil engineer of Glenfield, Pa., died on December 3, 1936. Mr. Leeper was born in Hookstown, Pa., on February 1, 1868, and graduated from Lafayette College in 1892. In 1897, after four years in railroad work, Mr. Leeper entered the employ of the American Bridge Company in Pittsburgh, Pa., where he remained until his retirement in 1934. He engaged in bridge and building design for his organization, and for a number of years was manager of the tower department. Mr. Leeper was the author of a handbook on transmission towers, which is used by engineering schools and engineers.

FRANK PAPE MCKIBBEN (M. '05) consulting engineer of Fayetteville, Pa., died there on November 27, 1936, at the age of 65. Mr. McKibben was born at Fort Smith, Ark., and was educated at the University of Arkansas and Massachusetts Institute of Technology. He taught civil engineering at the latter institution from 1894 to 1907, and served as professor of civil engineering at Lehigh University from 1907 to 1919 and at Union College from 1919 to 1926. From 1924 to 1926 Mr. McKibben was also city engineer of Schenectady, N.Y., and in 1927 he became consulting engineer to the General Electric Company and in 1928 to the city of Rochester, N.Y. In 1929 he established his own consulting practice.

FRED BAILEY OREN (M. '19) president of Mautz and Oren, Inc., Effingham, Ill., died on September 29, 1936. Mr. Oren, who was 56, was born at Watseka, Ill. In 1898 he became a chainman in the employ of the Illinois Central Railroad Company, where he remained until 1915 in a variety of capacities, including that of assistant engineer in the maintenance department, supervisor of track, and division engineer on maintenance of way. From 1916 to 1918 Mr. Oren was again with this railroad. In 1921 he formed the contracting and engineering firm of Mautz and Oren.

SETH PERKINS (Assoc. M. '17) chief engineer, WPA for Florida, Miami, Fla., died in that city on November 11, 1936. Mr. Perkins was born in Boston, Mass., on April 22, 1887. From 1909 to 1913 he was with the Florida Coast Line Canal and Transportation Company as assistant engineer and, later, as principal assistant engineer and chief engineer. From 1913 to 1917 he was a member of the firm of Seth Perkins and Sons, civil engineers of St. Augustine, Fla. During the war he served in France as second lieutenant in the field artillery. In 1919 he established the contracting and engineering firm of Markle and Perkins in Miami, Fla., maintaining this practice until 1933. His firm was engaged in the construction of docks, piers, cofferdams, bridges, trestles, and other structures.

THERON MONROE RIPLEY (M. '11) consulting engineer of Buffalo, N.Y., and former military engineer, died in that city on November 30, 1936. Major Ripley, who was 68, was born in Macedon, N.Y., and educated at Marietta College in Ohio. In 1898, after early experience in railroad construction and as engineer for one of the first hydroelectric plants on the Missouri River, he enlisted in the Army, serving in Cuba and the Philippines. From 1905 to 1913 he was in the New York State Engineer's Office, being transferred to the State Highway Department in the latter year. After service during the World War in the Engineers Corps of the U. S. Army, Major Ripley was placed in charge of the western New York division of the barge canal system, resigning in 1926 to become chief engineer of the Erie County highway system. In 1930 he established a consulting practice.

JOHN JERVIS VAIL (M. '31) engineer of construction for the Pennsylvania Railroad, Rahway, N.J., died in Norfolk, Va., on December 2, 1936, at the age of 59. Mr. Vail was born in Rahway and graduated from Rutgers University in 1898. Following graduation, he entered the employ of the Pennsylvania Railroad as a rodman. From 1900 to 1917 he was field engineer in charge of work on various construction, track elevation and extension, and other projects. From 1918 to 1924 he was assistant engineer for the railroad at Meadows Yard, N.J. In 1925 he became engineer of construction, serving in connection with the rebuilding of the Journal Square Station in Jersey City, the construction of bridges over Newark Bay and the Hackensack River, and numerous other projects.

Changes in Membership Grades

Additions, Transfers, Reinstatements, and Resignations

From November 10 to December 9, 1936, Inclusive

ADDITIONS TO MEMBERSHIP

ALBOHN, WILLIAM PHILLIP (Jun. '36), West 1408 Carlisle Ave., Spokane, Wash.

ALGERT, HENRY WELLS (Assoc. M. '36), Asst. Engr., U. S. Bureau of Reclamation, Roosevelt, Ariz.

ANDERSON, ARVAL LLOYD (Assoc. M. '36), Engr., U. S. Forest Service, Washington, D.C.

ANDERSON, THOMAS WILLIAM (Jun. '36), Mass. Inst. Tech. Graduate House, Cambridge, Mass.

ANDRUS, FREDERICK MARIAN (Jun. '36), 342 West 52d St., Los Angeles, Calif.

ARMENTROUT, JOHN BENJAMIN (Jun. '36), Engr., College Park Building Corporation, College Park (Res., 4613 Highland Ave., Bethesda), Md.

AUSTIN, GARRY HECKMAN (Jun. '36), 4830 Raleigh St., Denver, Colo.

BANKS, HARRY ROSEBOOM (Assoc. M. '36), Asst. Res. Engr. Insp., PWA, 3407 Glenhurst Ave., Los Angeles, Calif.

TOTAL MEMBERSHIP AS OF DECEMBER 9, 1936

Members	5,654
Associate Members	6,006
Corporate Members	11,660
Honorary Members	24
Juniors	5,299
Affiliates	87
Fellows	1
Total	15,071

BARBER, JESSE BYRON (Jun. '36), 106 Webb St. Pullman, Wash.

BARRUS, WINFORD MELVIN (Jun. '36), Asst. Irrig. Engr., R.A. (Res., 263 West Center St.), Logan, Utah.

BENNETT, PAUL DENNEY (Jun. '36), 6137 Kenwood Ave., Chicago, Ill.

BLACK, WINSTON EDWARD (Jun. '36), Fritz Eng. Laboratory, Dept. of Civ. Eng., Lehigh Univ., Bethlehem, Pa.

BLUMBERG, CHARLES (Jun. '36), 310 West 80th St., New York, N. Y.

BOVAY, HARRY ELMO, JR. (Jun. '36), Y. M. C. A., Vicksburg, Miss.

BOWEN, FRANK MILTON (M. '36), Engr. (Jensen, Bowen & Farrell), 209 Michigan Theatre Bldg., Ann Arbor, Mich.

BRIGANTI, THEODORE (Jun. '36), 1920 University Ave., New York, N.Y.

BURNS, DANIEL WILLIAM (Jun. '36), 80 Marlborough St., Boston, Mass.

BURNS, THOMAS STEPHEN (M. '36), Prin. Asst., U. S. Engr. Office, Denison, Tex.

BURR, PERCY NELSON (M. '36), Cons. Engr. (Runyon & Carey), 31 Fulton St., Newark (Res., 1072 Pine Ave., Union), N.J.

BUTLER, JOHN SOULE (Jun. '36), Rodman, C. M. St. P. & P. R. R., M. of W. Dept., Div. Engrs. Office, Savanna, Ill.

BUTTERS HAROLD AARON, JR. (Jun. '36), 6 Lombard Court, Augusta, Me.

CAMERON, HARRY ROBERT (Jun. '36), Draftsman, Pittsburgh Bridge & Iron Works (Res., 322 Jefferson St.), Rochester, Pa.

CARLSON, CONRAD VICTOR (Jun. '36), Field Engr., Eng. Dept., Nebraska Board of Control, Lincoln (Res., Axtell), Nebr.

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Strickland, Richard Porter (Jun. '27; Assoc. M. '36), Asst. Civ. Engr., RA (Res., 1426 Twenty-First St., N.W.), Washington, D.C.

Van Buren, Miles Herbert (Jun. '24; Assoc. M. '26; M. '36), Instr., Civ. Eng., Cooper Union; With Barney-Ahlers Const. Co., New York (Res., 63 Fort Greene Pl., Brooklyn), N.Y.

Weaver, Frederic Nixon (Assoc. M. '25; M. '36), Prof., Civ. Eng., Tufts Coll., Tufts College (Res., 29 Adams St., Medford Hillside), Mass.

Whitmore, George Dewey (Assoc. M. '25; M. '36), Chf., Surveys Section, Eng. Service Div., TVA, 701 Pound Bldg., Chattanooga, Tenn.

Whittelsey, Charles Chauncey (Jun. '28; Assoc. M. '30; M. '36), Staff Engr., Ford, Bacon & Davis, Inc., 39 Broadway, New York, N.Y.

Reinstatements

Brigham, Leslie Elijah, M., reinstated Nov. 9, 1936.

Cook, Auley Almerin, Assoc. M., reinstated Nov. 9, 1936.

Hallquist, Stone Conrad, Assoc. M., reinstated Nov. 9, 1936.

Jost, Charles Frederic, Jun., reinstated July 2, 1936.

Warner, Raymond Aloysius, Assoc. M., reinstated Nov. 9, 1936.

Willis, Charles Leyton, Jr., Assoc. M., reinstated Aug. 17, 1936.

Resignations

Ericson, Frederick Anson, M., resigned Nov. 11, 1936.

Falco, Macho, Assoc. M., resigned, Dec. 3, 1936.

Hebard, Roy William, M., resigned Nov. 18, 1936.

Hoar, William Hughes, Jun., resigned Nov. 11, 1936.

Houston, Hale, Affiliate, resigned Dec. 7, 1936.

Jordan, Myron Kendall, Assoc. M., resigned Nov. 24, 1936.

Knapp, John Herbert, M., resigned Nov. 6, 1936.

Knox, Samuel Lippincott Griswold, M. resigned Dec. 3, 1936.

Mann, Herbert Eichholz, Jun., resigned Dec. 3, 1936.

Schreiber, Harry William, Assoc. M., resigned Nov. 30, 1936.

Stankewich, Michael Joseph, Jun., resigned Dec. 3, 1936.

Stevens, Elihu William, Assoc. M., resigned Nov. 27, 1936.

Thomson, Fred Morton, Assoc. M., resigned Nov. 27, 1936.

Weigand, George Andrew, Assoc. M., resigned Dec. 4, 1936.

Wentworth, Chester Keeler, Affiliate, resigned Nov. 20, 1936.

Applications for Admission or Transfer

Condensed Records to Facilitate Comment of Members to Board of Direction

January 1, 1937 — NUMBER 1

The Constitution provides that the Board of Direction shall elect or reject all applicants for admission or for transfer. In order to determine justly the eligibility of each candidate, the Board must depend largely upon the membership for information.

Every member is urged, therefore, to scan carefully the list of candidates published each month in CIVIL ENGINEERING *and to furnish the Board with data which may aid in determining the eligibility of any applicant.*

It is especially urged that a definite recommendation as to the proper grading be given in each case, inasmuch as the grading must be based upon the opinions of those who know the applicant personally as well as upon the nature and extent of his professional experience. Any facts derogatory to the personal character or professional reputation of an applicant should be promptly communicated to the Board.

Communications relating to applicants are considered strictly confidential.

The Board of Direction will not consider the applications herein contained from residents of North America until the expiration of 30 days, and from non-residents of North America until the expiration of 90 days from the date of this list.

MINIMUM REQUIREMENTS FOR ADMISSION

Grade	General Requirement	Age	Length of Active Practice	Responsible Charge of Work
Member	Qualified to design as well as to direct important work	35 years	12 years*	5 years of important work
Associate Member	Qualified to direct work	27 years	8 years*	1 year
Junior	Qualified for sub-professional work	20 years †	4 years*	
Affiliate	Qualified by scientific acquirements or practical experience to cooperate with engineers	35 years	12 years*	5 years of important work
Fellow	Contributor to the permanent funds of the Society			

* Graduation from an engineering school of recognized reputation is equivalent to 4 years of active practice.
† Membership ceases at age of 33 unless transferred to higher grade.

The fact that applicants refer to certain members does not necessarily mean that such members endorse.

ADMISSIONS

AIVAZIAN, HARRY, New York City. (Age 35.) Refers to R. E. Horton, H. T. Leach, O. C. Merrill, G. J. Requardt, M. R. Scheidt, B. LeC. Smith, E. B. Whitman.

ALLARDICE, WILLIAM DUNCAN, Philadelphia, Pa. (Age 36.) Supt. of Constr., M. H. McCloskey Co. Refers to C. P. Bower, H. B. Luther, G. R. Ramsey, R. W. Renn, H. Schneider, P. H. Turnbull, D. B. Ventres.

ANDERSEN, RHUEL ANDREW, Knoxville, Tenn. (Age 27.) Asst. Structural Engr., TVA. Refers to D. A. Buzzell, E. E. Halmos, P. F. Keim, J. G. Mason.

BAUER, ARCHIBALD BARTHULY, Columbus, Nebr. (Age 27.) Computer, Harza Eng. Co. on Loup River Power Project. Refers to H. A. Beckwith, C. H. James, C. E. Mickey.

BERNSTEIN, WILLIAM MAURICE, New York City. (Age 21.) Refers to W. Allan, R. E. Goodwin, J. C. Rathbun.

BLACKER, CARROLL LYNNE, Palo Alto, Calif. (Age 35.) Chf. Bldg. Inspector, City of Palo Alto, Calif. Refers to L. H. Anderson, J. F. Byxbee, E. L. Grant, C. D. Marx, L. B. Reynolds, E. C. Thomas, C. B. Wing.

BRODERICK, JOHN HENRY, Boston, Mass. (Age 57.) J. H. Broderick Co., Inc., Engrs. and Gen. Contrs. Refers to E. F. Allbright, B. S. Brown, F. H. Fay, C. R. Gow, M. Linenthal, E. A. Varney.

BUEHLER, BOB JOHN, Knoxville, Tenn. (Age 26.) Jun. Hydr. Engr., TVA, Flood Control and Sanitation Sec., Project Planning Div. Refers to J. S. Bowman, F. M. Dawson, D. E. Donley, J. H. Kimball, E. J. Rutter.

CALDWELL, WILLIAM WEBSTER, New York City. (Age 36.) With The J. G. White Eng. Corporation. Refers to C. M. Africa, R. A. Backus, A. S. Crane, G. Dunn, S. R. Jones, F. Kurtz, C. S. Proctor, F. A. Rossell, S. F. Voorhees, E. G. Williams.

CARVER, ROY JAMES, Springfield, Ill. (Age 27.) With State Dept. Public Works and Bldgs., Div. of Highways. Refers to G. F. Burch, J. O. Draffin, E. D. Dryfoose, H. E. Eckles, H. H. Jordan, C. E. Morgan, L. E. Philbrook, W. N. Schroeder, J. Vawter, R. L. Whannel.

CASANUEVA, RUPERTO, New York City. (Age 24.) Asst. in Hydraulic Eng., Univ. of Chile; at present in United States commissioned by Chilean Govt. and Univ. of Chile to study hydraulics, industrial engineering, etc. Refers to B. A. Bakhmeteff, A. Decombe, B. A. Etcheverry, C. G. Hyde, L. Lira Manso.

CLORE, ROBERT HENRY JOSEPH, Muncie, Ind. (Age 24.) Refers to C. A. Ellis, R. B. Wiley.

CORNEY, WILLIAM HARRY VICTOR, Adelaide, South Australia. (Age 43.) Eng. Surveyor, Eng. & Water Supply Dept., acting as Asst. Res. Engr. Refers to J. Mulholland, R. C. Robin. (Applies in accordance with Sec. 1, Art. I, of the By-Laws.)

DAIGLE, JOSEPH EDGAR, Berkeley, Calif. (Age 27.) Refers to R. E. Davis, B. Jameyson.

DANEL, PIERRE FRANCOIS, Grenoble, France. (Age 34.) Research Engr., Hydraulic Laboratory, Ateliers Neyret-Beylier Piccard-Pictet, also Director, Hydr. Laboratory, School of Eng. Hydraulics. Refers to C. M. Allen, E. S. Cole, R. T. Knapp, E. W. Lane, M. P. O'Brien, K. C. Reynolds, D. L. Yarnell.

DAVISON, IRA MILTON, Hartford, Conn. (Age 22.) Refers to H. B. Compton, P. Schultze.

DOWLING, WALLACE EUGENE, Lincoln, Nebr. (Age 27.) Bridge Designer, Nebraska Dept. of Roads and Irrigation. Refers to W. Grant, J. G. Mason, A. L. Ogle, H. G. Schlitt, J. Sorkin, C. E. Spellman.

DOWNS, ROSCOE PHILLIPS, Rice, Calif. (Age 29.) Engr. with Jahn & Bressi Constr. Co., Inc., Los Angeles, Calif. Refers to N. F. Jahn, R. R. Martel, D. C. May, W. W. Michael, F. Thomas, W. E. Whittier, C. W. Wood.

DRECHSLER, MEYER, Long Beach, N.Y. (Age 44.) Res. Engr. Inspector, FEA of PW. Refers to L. L. Balleisen, A. Brahdy, A. E. Howland, O'K. W. Myers, M. Turk.

ECKLUND, CONRAD ARTHUR, Glendale, Calif. (Age 50.) Senior Topographic Engr., U. S. Geological Survey, acting as Sec. Chf. Refers to C. E. Arnold, C. H. Birdseye, R. T. Evans, H. H. Hodgeson, A. Jones, G. S. Smith, J. G. Staack.

ENDERLIN, HAROLD CECIL, Vacaville, Calif. (Age 26.) Project Designing Engr., U. S. Soil Conservation Service. Refers to R. A. Floyd, G. W. Gosline, E. L. Grant, C. Moser, L. B. Reynolds.

EPPS, THAD CHANDLER, Minneapolis, Minn. (Age 36.) Bldg. Inspector, Inspection Div., PWA. Refers to R. G. Alexander, H. L. Crandall, W. E. King, A. H. Newman, C. E. Palmer.

FERNANDEZ, MIGUEL ANGEL, New York City. (Age 26.) Instrumentman, WPA, City of New York. Refers to R. E. Goodwin, J. C. Rathbun.

FISCHER, PHILIP CONRAD, New York City. (Age 29.) Draftsman, Electrolysis Div., Dept. of Water Supply, Gas & Electricity. Refers to J. Goodman, C. T. Schwarze, D. S. Trowbridge.

FOSTER, WILLIAM SOUTHMAYD, Ames, Iowa. (Age 26.) Paving Inspector, Iowa Highway Comm. Refers to T. R. Agg, A. H. Fuller, W. E. Galligan, J. H. Griffith, F. Kerekes, M. B. Morris, L. O. Stewart.

FOX, FREDERICK JAY, New York City. (Age 42.) Res. Engr., PWA. Refers to F. S. Childs, A. Dick, J. Feld, B. Schwerin, A. V. Sielke.

GADDY, JOHN WILLIAM, Welch, W.Va. (Age 41.) With A. Farnell Blair, Contr., Lake Charles, La. Refers to J. P. Bonner, E. F. Ketter, R. A. Nowlin, H. M. Scott, H. S. Slocum.

GAFFNEY, ARTHUR THOMAS, Brooklyn, N.Y. (Age 21.) Refers to J. J. Costa, C. J. Sheridan.

GARDNER, JULIUS BRADEN, Knoxville, Tenn. (Age 30.) Jun. Hydr. Engr., TVA. Refers to D. E. Donley, N. W. Dougherty, J. H. Kimball, E. J. Rutter, J. Wright.

GIGSTAD, KNUT, New York City. (Age 31.) Senior Engr., WPA, Parks Dept. Refers to A. M. Anderson, R. C. Brumfield, F. E. Foss, L. Funk, J. Wilmot.

GOTT, ESTEP TILLARD, Pittsburgh, Pa. (Age 53.) Vice-Pres., Dravo Contr. Co. Refers to A. W. Dann, H. N. Eavenson, J. F. Leonard, W. R. Okeson, A. J. Sackett, F. E. Winsor.

GREEN, EARL, Sacramento, Calif. (Age 34.) Jun. Highway Engr., U. S. Bureau of Public Roads. Refers to E. C. Brown, G. L. McLane, J. L. Mathias, C. C. Morris, W. H. Smith, C. H. Sweetser.

Gre[illegible], Joseph John, Melbourne, Vic., Australia. (Age 51.) In private practice. Refers to J. T. N. Anderson, C. F. Blain. (Applies in accordance with Sec. 1, Art. I, of the By-Laws.)

Han[illegible]m, Erwin Charles, New York City. (Age 28.) Tutor, School of Technology, Coll. of City of New York. Refers to W. Allan, S. N. Grimm, G. D. Holmes, L. Mitchell.

Harris, Walter Clarence, San Leandro, Calif. (Age 26.) Jun. Bridge Constr. Engr., State of California, being Asst. Res. Engr. on grade-separation projects. Refers to E. C. Bissell, O. R. Bosso, S. T. Harding, B. Jameyson, F. W. Panhorst, H. H. Wheaton.

Hayes, Howard Maxwell, Murphy, N.C. (Age 27.) Asst. Eng. Aide, TVA, acting as Rodman, Recorder, Computer, and Instrumentman. Refers to O. B. Bestor, J. D. Blagg, P. H. La Rosee, C. L. Mann, R. L. Moore, H. Tucker, G. D. Whitmore.

Hearn, Chauncey Martin, Providence, R.I. (Age 32.) Jun. Engr., U. S. Engr. Dept. Refers to C. E. Boesch, W. A. Hadley, S. S. Jacobs, W. A. Read, W. R. Vawter.

Hough, Ulysses B., Spokane, Wash. (Age 73.) Civ. and Cons. Engr. Refers to C. A. Burnette, A. D. Butler, E. H. Collins, W. L. Malony, E. G. Taber, A. J. Turner.

Houghtaling, Byron, New York City. (Age 50.) Div. Engr. with Board of Transportation. Refers to W. McK. Griffin, A. Lyle, T. F. McQuade, R. Ridgway, J. B. Snow, H. D. Winsor.

Hutchinson, Homer Brinson, Jr., Guntersville Dam, Ala. (Age 27.) Inspector, Constr. Engr.'s Office, TVA. Refers to V. Gongwer, E. H. Morgan, C. M. Strahan, F. W. Truss.

Irwin, William Bentley, St. Paul, Minn. (Age 49.) Asst. to Vice-Pres., Operation, Great Northern Ry. Refers to O. S. Bowen, E. B. Crane, J. R. W. Davis, D. J. Kerr, H. S. Loeffler, C. M. Nye, L. Yager.

Ivy, Raymond Jennyings, Berkeley, Calif. (Age 29.) Jun. Bridge Engr., Bridge Dept., California Div. of Highways. Refers to T. E. Ferneau, G. A. Greene, F. W. Panhorst.

Jenkins, Herbert Theodore, Ithaca, N.Y. (Age 34.) Asst. Prof. of Civ. Eng., Cornell, Univ. Refers to L. E. Ayres, F. A. Barnes, E. L. Eriksen, L. M. Gram, S. C. Hollister, R. Norris.

King, Charles Grant, Knoxville, Tenn. (Age 27.) Eng. Aide, Planning Div., TVA. Refers to H. H. Block, J. S. Bowman, D. E. Donley, G. E. Tomlinson, G. O. Wessenauer.

Knudsen, Clarence Virgil, Lincoln, Nebr. (Age 27.) Bridge Detailer, Nebraska Dept. of Roads and Irrigation. Refers to C. M. Duff, H. J. Kesner, J. G. Mason, C. E. Mickey, A. L. Ogle, H. G. Schlitt.

Little, Andrew Jackson, Jr., Jacksonville, Fla. (Age 39.) Asst. State Director, Div. of Operations, Florida WPA. Refers to M. B. Garris, B. P. McWhorter, H. D. Mendenhall, A. F. Perry, Jr., W. E. Robinson.

Lofft, Henry Tuttle, Pickwick Dam, Tenn. (Age 40.) Office Engr., TVA. Refers to C. D. Babcock, H. W. English, C. E. Haywood, J. W. Moffett, R. F. Olds, J. L. Orr, A. L. Pauls.

Lord, Herbert Overton, Madison, Wis. (Age 40.) Chf. Engr., Madison Metropolitan Sewerage Dist. Refers to S. A. Greeley, D. W. Mead, H. W. Mead, C. V. Seastone, C. N. Ward.

Loveland, Chester H., San Francisco, Calif. (Age 48.) Pres., The Loveland Engrs., Inc. Refers to E. R. Bowen, A. J. Cleary, N. A. Eckart, G. W. Hawley, C. H. Lee, S. B. Morris, F. M. Randlett.

Mann, Warren Staten, Atlanta, Ga. (Age 35.) Chf. Engr., The Dixie Culvert & Metal Co. Refers to C. L. Mann, T. M. Neibling, M. C. Patton, J. B. Pridgen, H. Tucker, I. G Tuttle.

Matthias, Franklin Thompson, Fountain City, Tenn. (Age 28.) Asst. Civ. Engr., TVA. Refers to A. J. Ackerman, J. S. Bowman, O. Laurgaard, D. W. Mead, F. E. Turneaure, L. F. Van Hagan, D. M. Wood.

Maxwell, Clyde Vernon, Jr., Ringgold, Ga. (Age 24.) With TVA. Refers to A. B. Hargis, R. B. B. Moorman.

Mills, John Pardon, Jr., Lynnhaven, Va. (Age 25.) Chf. of Party, Truck Traffic Survey, Virginia Highway Dept. Refers to R. B. H. Begg, F. J. Sette.

Moore, Arthur Joseph, San Benito, Tex. (Age 33.) Office Engr. (Rating Asst. Engr.), International Boundary Comm., Lower Rio Grande Flood-Control Project. Refers to W. W. Hall, L. M. Lawson, J. L. Lytel, E. N. Noyes, F. C. Scobey, A. Tamm.

Mruz, John Mathew, Tallahassee, Fla. (Age 22.) Project Clerk with Director, Florida Construction Program, State Institutions. Refers to W. W. Fineren, N. W. Green, R. M. Johnson, T. M. Lowe, P. L. Reed.

Nixon, Daniel Decatur, Corpus Christi, Tex. (Age 27.) Instrumentman, Div. Office, Texas Highway Dept. Refers to M. Johnson, J. T. L. McNew, J. C. McVea, J. J. Richey, J. G. Rollins, R. W. Stiles, H. P. Stockton, Jr.

Reid, John Henry, New York City. (Age 27.) Constr. Engr. with Thomas F. Bowe, Cons. Engr., on Westwood sewage-treatment plant extension. Refers to H. R. Codwise, L. H. Csanyi, E. J. Squire.

Reynolds, Francis Marion, Sacramento, Calif. (Age 36.) Asst. Engr., California Div. of Highways. Refers to T. A. Bedford, R. M. Gillis, F. J. Grumm, J. H. Obermuller, C. S. Pope, R. H. Wilson.

Robinson, James Burnham, Christiansted, St. Croix, Virgin Islands. (Age 26.) Jun. Civ. Engr., Dept. of Interior, F.P.-16. Refers to C. H. Cotter, O. B. French, E. B. Gayler, J. R. Lapham.

Rountree, Jack Roberts, Knoxville, Tenn. (Age 22.) Jun. Eng. Draftsman, Dams Div., Eng. Design Dept., TVA. Refers to R. P. Black, F. C. Snow.

Sawyer, Alfred Worcester, New York City. (Age 25.) Jun. Asst. Engr. with Malcolm Pirnie, Cons. Engr. Refers to G. M. Fair, A. Haertlein, M. Pirnie, R. W. Sawyer, 3d.

Sawyer, Robert Kenneth, Duluth, Minn. (Age 25.) Instructor in Civ. Eng., Duluth, Jun. Coll. Refers to H. Bouchard, W. J. Emmons, L. C. Maugh, R. L. Morrison, R. H. Sherlock, C. O. Wisler, J. S. Worley.

Shea, Herman James, Boston, Mass. (Age 25.) Instructor, Massachusetts Inst. of Technology, Cambridge, Mass. Refers to H. G. Avers, J. B. Babcock, 3d, W. Bowie, C. B. Breed. J. W. Howard, J. D. Mitsch, F. L. Peacock.

Shea, Joseph Thomas, Boston, Mass. (Age 39.) Constr. Engr., Bldg. Dept. Refers to W. M. Bailey, B. S. Brown, M. F. Brown, L. F. Ellis, J. E. Hanlon, O. H. Horovitz, M. Linenthal, E. A. Norwood, S. W. Orr, M. A. Reidy, G. E. Strehan, E. A. Tucker, E. A. Varney, A. C. Waghorne, F. S. Wells.

Sherman, Leslie Kimber, West Hartford, Conn. (Age 29.) Senior San. Engr., Connecticut State Dept. of Health. Refers to B. L. Bigwood, H. P. Burden, G. M. Fair, W. J. Scott, F. N. Weaver.

Smith, Frederik Egid, Houston, Tex. (Age 51.) Res. Engr. Inspector, PWA. Refers to J. B. Dannenbaum, W. W. Hall, J. M. Howe, H. A. Levering, J. G. McKenzie, J. C. McVea, T. A. Polansky, F. H. Shaw, A. J. Wise.

Smith, Warren Austin, Jacksonville, Fla. (Age 51.) Cons. Engr. Refers to G. H. Cairns, J. H. Dowling, J. A. Hammack, G. B. Hills, J. A. Long, W. N. McDonald, H. D. Mendenhall, R. E. Spaulding.

Stanley, Randolph Lee, Antioch, Calif. (Age 25.) Transitman, U. S. Bureau of Reclamation. Refers to C. G. Hyde, H. M. Rich, O. G. Stanley.

Starr, Mark Elwood, Pottsville, Pa. (Age 23.) Refers to C. L. Harris, R. L. Sackett.

Stokes, Herbert Raymond, Knoxville, Tenn. (Age 25.) Civ. Eng. Aide, TVA. Refers to J. J. Doland, A. S. Fry.

Trively, Ilo Allely, Lincoln, Nebr. (Age 30.) Instructor, Univ. of Nebr. Refers to R. O. Green, D. H. Harkness, H. J. Kesner, C. E. Mickey, H. G. Schlitt, J. Sorkin.

Trueblood, Paul McGeorge, Seattle, Wash. (Age 52.) Structural Draftsman, Bridge Div., City Engr.'s Dept. Refers to L. M. Grant, R. R. Lukens, D. W. McMorris, O. A. Piper, E. L. Strandberg, M. O. Sylliaasen, F. F. Weld.

Van Zandt, Franklin Keller, Yakima, Wash. (Age 33.) Asst. Topographic Engr., U. S. Geological Survey. Refers to W. R. Chenoweth, H. H. Hodgeson, A. Jones, H. E. Phelps, M. K. Snyder, J. G. Staack.

Walters, James Erald, Pickwick Dam, Tenn. (Age 37.) Supt. of Constr., TVA. Refers to A. J. Ackerman, C. A. Bock, R. F. Olds, T. B. Parker, A. L. Pauls, O. Reed, R. White.

Weir, Paul, Atlanta, Ga. (Age 30.) Supt. of Water Purification and Chf. Chemist in charge of water-purification plants, with W. Z. Smith, Gen. Mgr., Atlanta Water-Works. Refers to R. P. Black, L. Cady, C. D. Gibson, M. T. Singleton, F. C. Snow, H. F. Wiedeman.

Wheeler, Frank Knowles Blasdell, Pearl Harbor, Hawaii. (Age 24.) Ensign, U. S. S. Minneapolis, U. S. Navy. Refers to H. K. Dougan, O. M. Leland, G. E. Loughland, B. Moreell, L. G. Straub, W. H. Wheeler.

Zala, George Thomas, Cleveland Heights, Ohio. (Age 38.) Structural Engr. with Geo. B. Gascoigne & Associates, Cons. San. Engrs., Cleveland, Ohio. Refers to A. A. Burger, C. G. French, W. L. Havens, W. L. Leach, F. C. Tolles.

Zampella, Albert Andrew, Paterson, N.J. (Age 29.) Chf. of Party with New Jersey Riparian Survey. Refers to W. N. Cervino, C. D. Geiger, R. Gray, A. S. Hobby, J. H. Whitney.

FOR TRANSFER

FROM THE GRADE OF ASSOCIATE MEMBER

Bergendoff, Ruben Nathanial, Assoc. M., Kansas City, Mo. (Elected Junior Jan. 15, 1923; Assoc. M. Oct. 1, 1928.) (Age 38.) Asst. Engr., Ash-Howard-Needles & Tammen. Refers to A. T. Granger, C. S. Harper, C. S. Heritage, E. E. Howard, E. R. Needles, H. C. Tammen, H. P. Treadway.

Chang, Han Ying, Assoc. M., Nanking, China (Elected Feb. 19, 1934.) (Age 36.) Vice-Director, Bureau of Hydr. Eng., National Economic Council. Refers to F. A. Barnes, H. Cross, S.-T. Hsu, S.-T. Li, H.-H. Ling, E. W. Schoder, C. C. Williams.

Davis, Charles McRea, Assoc. M., Takoma Park, D.C. (Elected Aug. 30, 1926.) (Age 43.) Senior Civ. Engr. and Coordinator, Farm Tenant Security Project, Resettlement Administration, Washington, D.C. Refers to J. S. Hancock, G. L. Hughes, G. Miller, A. N. Outzen, J. W. Reid, H. A. Shuptrine.

Fucik, John Frank, Jr., Assoc. M., Chicago, Ill. (Elected Jan. 14, 1924.) (Age 51.) Asst. Engr., Chicago Board of Local Improvements. Refers to C. B. Burdick, E. J. Fucik, P. E. Green, J. B. Hittell, A. J. Schafmayer, H. E. Young.

Hale, Hal Henderson, Assoc. M., Knoxville, Tenn. (Elected Junior Jan. 19, 1925; Assoc. M. Oct. 14, 1930.) (Age 35.) City Engr. Refers to B. B. Brier, N. W. Dougherty, A. S. Fry, J. P. Growdon, C. E. McCashin, F. E. Murphy, W. G. Stromquist.

MEANS, BOYD IRWIN, Assoc. M., Los Angeles, Calif. (Elected March 16, 1925.) (Age 49.) Cons. Structural Engr. Refers to E. B. Black, H. W. Bolin, F. A. Johnson, A. P. Learned, H. McCurdy, C. A. Smith, N. T. Veatch, Jr., V. Wood.

OLSON, LELAND ALFRED, Assoc. M., Cleveland, Ohio. (Elected Jan. 13, 1930.) (Age 37.) Structural Designer, Bridge Dept., Nickel Plate R.R. Refers to O. E. Hager, W. L. Havens, E. A. Kemmler, G. F. Pfeiffer, F. L. Plummer, G. H. Tinker, F. C. Tolles.

PECKWORTH, HOWARD FARON, Assoc. M., Oneonta, Ala. (Elected Junior March 14, 1927; Assoc. M., July 27, 1931.) (Age 35.) Res. Engr., Birmingham Industrial Water-Supply Comm. Refers to G. E. Beggs, F. L. Cranford, C. H. Locher, H. O. Locher, J. R. Monaghan, A. C. Polk, C. S. Proctor, L. G. Warren.

WAHLER, JOSEPH AUGUST, Assoc. M., Chula Vista, Calif. (Elected Dec. 5, 1927.) (Age 43.) Supt. of Constr. and Civ. Engr., Public Works Dept., 11th Naval Dist., San Diego, on WPA project, San Clemente Island. Refers to C. L. Eckel, G. A. McKay, S. S. Neff, F. D. Pyle, A. S. Toth.

FROM THE GRADE OF JUNIOR

BOGARDUS, THEODORE S., Jun., Meadville, Pa. (Elected June 4, 1928.) (Age 32.) Asst. City Engr.; also Instructor, Allegheny Coll. Refers to W. A. Doane, F. W. Herring, L. D. Matter, W. W. C. Perkins, C. L. Siebert, E. H. Stumpf.

CAMPBELL, FRANK BIXBY, Jun., Spartanburg, S.C. (Elected July 16, 1928.) (Age 32.) Associate Soil Conservationist, Soil Conservation Service. Refers to R. Follansbee, R. C. Gowdy, E. W. Lane, D. D. Price, J. L. Savage, E. W. Schoder, E. B. Whitman.

COSGROVE, FRANK HESTER, Jun., Worcester, Mass. (Elected Oct. 1, 1928.) (Age 32.) Jun. Engr., U. S. Forest Service. Refers to C. A. Betts, C. R. Bliss, R. W. Burpee, G. R. Meiers, J. A. Tosi.

GWIN, LEWIS LYNDSAY, Jun., Harrisburg, Pa. (Elected Dec. 3, 1928.) (Age 30.) Engr., Grade 14, PWA, State Director's Office. Refers to G. D. Andrews, G. S. Beal, W. H. Gravell, N. B. Jacobs, G. F. Pawling, P. H. Turnbull, E. D. Walker.

HESTER, ELMER WEBB, Jun., Austin, Tex. (Elected April 27, 1931.) (Age 32.) Res. Engr., Texas State Highway Dept. Refers to O. V. Adams, G. A. Field, J. H. Murdough, H. N. Roberts, G. G. Wickline.

HILTON, RALPH LIVINGSTON, Jun., Alhambra, Calif. (Elected Dec. 3, 1926.) (Age 33.) With Eng. Dept., The Paraffine Companies, Inc., Los Angeles, Calif. Refers to L. A. Elsener, G. T. Horton, C. H. Scheman, F. W. Schooley, M. J. Trees.

JELLEY, JOSEPH FRANKLIN, JR., Jun., Norfolk, Va. (Elected Oct. 26, 1931.) (Age 32.) Asst. Public Works Officer, C.E.C., U. S. Navy. Refers to A. G. Bissett, A. Hoar, J. J. Manning, P. L. Reed, E. C. Seibert, R. E. Thomas, R. M. Warfield.

JOST, CHARLES FREDERICK, Jun., New York City. (Elected June 10, 1929.) (Age 32.) Member of firm, Nicholas S. Hill, Jr., Cons. Engr. Refers to A. N. Aeryns, E. H. Aldrich, G. H. Buck, C. M. Everett, M. Pirnie, A. Potter, A. P. Richmond, Jr., W. P. Seifert.

KEAVENY, FELIX JAMES, Jun., Balboa Heights, Canal Zone. (Elected Dec. 9, 1935.) (Age 32.) Structural Designer, The Panama Canal. Refers to M. R. Alexander, P. Andersen, R. E. Goodwin, R. L. Pfau, S. Rosenberg.

MACK, GEORGE JOHN, Jun., Niagara Falls, N.Y. (Elected Dec. 14, 1925.) (Age 32.) Estimator and Designer, Laur & Mack Contr. Co. Refers to W. McCulloh, F. N. Menefee, H. L. Noyes, A. P. Skaer, N. H. Sturdy.

MEYER, OTTO HERMAN, Jun., Boston, Mass. (Elected Oct. 26, 1931.) (Age 28.) Asst. Engr., U. S. Engr. Dept. Refers to H. J. Casey, E. C. Constance, A. L. Hyde, E. J. McCaustland, G. R. Rich, E. F. Robinson, H. K. Rubey.

WAGNER, RICHARD ALLEN, Jun., Los Angeles, Calif. (Elected Oct. 14, 1930.) (Age 29.) Engr. of Investigations, Bridge Dept., Div. of Highways, State of California. Refers to H. S. Comly, J. Gallagher, W. H. Johnson, F. W. Panhorst, D. R. Warren, P. R. Watson.

WILL, CURT HESSE, Jun., Ann Arbor, Mich. (Elected April 18, 1927.) (Age 32.) Senior Engr., Jensen, Bowen & Farrell, Appraisal Engrs. Refers to F. M. Bowen, K. A. Farrell, L. M. Gram, H. K. Hood, O. A. R. V. Jensen, H. E. Riggs.

The Board of Direction will consider the applications in this list not less than thirty days after the date of issue.

Men Available

These items are from information furnished by the Engineering Societies Employment Service, with offices in Chicago, New York, and San Francisco. The Service is available to all members of the contributing societies. A complete statement of the procedure, the location of offices, and the fee is to be found on page 87 of the 1936 Year Book of the Society. To expedite publication, notices should be sent direct to the Employment Service, 31 West 39th Street, New York, N.Y. Employers should address replies to the key number, care of the New York Office, unless the word Chicago or San Francisco follows the key number, when it should be sent to the office designated.

CONSTRUCTION

CONSTRUCTION ENGINEER-ESTIMATOR; Assoc. M. Am. Soc. C.E.; architectural graduate; 3 years civil engineering study; 38; married; 7 years experience in construction departments of major oil company, public utility corporation, and industrial companies in field supervision and office engineering; 9 years with large construction companies as building cost estimator, construction engineer, purchasing and contact work. Now available. C-2146.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; age 35; married; 9 years as construction engineer with state highway department; 3 years general engineering in West Indies and Central America. Speaks Spanish. Desires connection promising some degree of permanence in construction, planning, or location. D-5424.

CONSTRUCTION ENGINEER AND SURVEYOR; Assoc. M. Am. Soc. C.E.; 35; married; C.E., Princeton University; 8 years on railroad surveys, construction, and maintenance; 3 years varied experience in construction, valuation, drafting, etc. Especially qualified for layout and supervision of construction and handling survey parties. Location immaterial. Detailed experience record sent on request. D-1027.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 27; married; B.E. in C.E., Vanderbilt University, 1930; 6 years experience as draftsman, timekeeper, and inspector. Hydroelectric projects, bridge construction, channel control work; also reinforced concrete and structural steel design. Interested in position in East. D-5586.

DESIGN

STRUCTURAL DESIGNER; Jun. Am. Soc. C.E.; B.S. in C.E., 1925; L.L.B., 1934; age 33; topographical experience, 3 years; subway and elevated structural design, $3^1/_2$ years; teaching, 5 years; reinforced concrete buildings, 6 months; available now. B-9342.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; graduate; registered professional engineer; age 46; married; 8 years association with consulting engineers on design and construction of hydroelectric and steam plants, reports, valuations. Wide experience in hydrology, hydraulics, and flood control. Location, east. Available on reasonable notice. D-113.

EXECUTIVE

GRADUATE CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; age 47; married; with valuation, management, personnel, and organization experience; now regional chief of Architectural and Engineering Planning Resettlement Administration in South. Desires new location. Will consider temporary assignment. Location in the East desired. C-2015.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; New Jersey license; B.S., C.E.; 36; married; 16 years experience on surveys, estimates, design, and construction of harbor facilities, power transmission lines, steel and reinforced concrete bridges. Past two years with bridge and drainage engineer on 750 miles of road work. Desires connection with organization offering opportunity for future advancement. D-2493.

ENGINEER CONSTRUCTION; M. Am. Soc. C.E.; Transvaal Republic; engineer officer in Boer War; in America 1902, architect Missouri Pacific Railroad; designed buildings, Worlds Fair, St. Louis, 1903–1904; chief engineer, City Building Department, St. Louis, 1904–1920; architect and engineer designing, supervising large buildings; translates technical articles, German-English; prefers position as municipal architect. D-5538.

ENGINEER; Assoc. M. Am. Soc. C.E.; graduate; New York State license; 34; married; 13 years experience in municipal water-works field-analysis, design, maintenance, operation. Fluent French, Spanish, some German. Capable of handling men. Available on reasonable notice. D-5451.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; graduate civil engineer; age 46; married; 24 years experience, city planning transportation studies, traffic research field surveys, industrial buildings and plant layout, mechanical installations and maintenance of equipment. Now available. Location immaterial. C-7958.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 47; married; graduate of University of Wisconsin. Experienced in oil refinery construction and maintenance, machine design, highways, sewerage, water supply, investigation, and surveys. Held positions of chief of party, chief draftsman, estimator, designer, resident engineer; 9 years with one company. Now employed. Available on notice of month or less. A-3318.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 30; single; graduate; trained at Purdue University